THE EAST AFRICAN AGRICULTURAL JOURNAL

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FOREWORD

The subject of outstanding and immediate interest to receive attention in this issue of the *Journal* is that of maize storage. The present shortage of maize emphasizes, more strongly than anything else could have done, the importance of ensuring that what the seasons permit us to harvest we do not waste.

In the sheath of the cob nature herself has provided a remarkably efficient protection against insect pests, but except for stocks on the smallest scale, considerations of space make it impossible to utilize this advantage. Some other native African methods of grain storage, in pits or mud-sealed containers, have also much to commend them, but it is for comparatively large supplies that special methods and special precautions are so insistently demanded.

In his article Mr. Harris analyses the factors that cause damage in store: throughout, the underlying recommendation is to ensure cleanliness and proper drying. The very efficiency of modern materials, metal and concrete, in protecting their contents from external influences, exaggerates the risk of damage through sweating if the grain has been stored before it is properly dry. The moisture content of maize varies with the general humidity of the local climate: and this stresses the need for grain harvested in cooler or damper weather to be dried with especial care before storage. In the struggle against insect pests we are at present almost deprived of the valuable weapon of fumigation because the necessary chemicals are so difficult to get. Mr. Harris suggests a partial alternative, but the main burden of his recommendations for minimizing insect damage are "cleanliness and dryness". He gives some details of bin construction and as a pendant to his article we reprint some valuable detailed instructions from the *Rhodesian Agricultural Journal*.

Another article to which we wish to draw special attention is that by Mr. Lowe on the possibilities of goats as a source of milk, especially in those areas infested with tsetse, where cattle will not survive. It is, unfortunately, not true that goats are immune to trypanosomiasis, but the local "native" strain of goat appears to be far more resistant than other domesticated animals. It remains to be seen how far this resistance can be retained when the goat is "graded up" by the infusion of better-yielding strains from overseas. In this connexion it is interesting to note that the preliminary breeding experiments at Mpwapwa show that Toggenburgs or Indian breeds are likely to be the best to introduce for crossing. Goats, however, resemble other domesticated animals in that European pure-breds or high-grades are not suited to hot climates.

Nobody who has once used the milk of goats is likely to retain any prejudice against it. The widespread opinion against the goat as the pre-eminent destroyer of the land has lately received some shrewd blows in this *Journal*. In the dietary interests of a large proportion of the people of East Africa it is greatly to be hoped that the production and use of good milking goats will spread widely.

A POINT OF SCIENTIFIC NOMENCLATURE

A scientific name is made up of, first the generic name, second, the specific name, and often a third name, that of the sub-species or variety. It has been the universal rule that the generic name should start with a capital letter. Zoologists all write both their specific and sub-specific or varietal names without capitals. The botanists have not been so consistent. Their Rules of Nomenclature, approved by international botanical congresses, recommend—though they do not insist—that specific and varietal names of certain types should be written with a capital letter. This introduces a refinement with which it is difficult for a worker to comply, unless he has a botanical library at his command and, moreover, it is often responsible for mistakes and waste of time in copying. Therefore the recommendation to use capitals for some specific names is not followed by many who are concerned with applied botany, especially in agriculture and forestry. This *Journal* will in future follow the lead given in this matter by the *Kew Bulletin Additional Series XII.* ("Cultivated Crop Plants of the British Empire and the Anglo-Egyptian Sudan (Tropical and Sub-tropical)" by H. C. Sampson.) We shall as a rule use a capital letter in scientific names only for the first, generic, name. If any author feels that his contribution is to "pure", rather than applied, botany and he wishes certain of his specific names to be capitalized he should refer especially to the point when he submits his manuscript.

MAIZE STORAGE

By W. Victor Harris, Entomologist, Department of Agriculture, Tanganyika

The greater part of the maize crop in East Africa is grown under conditions which permit of only one harvest a year. While it is true that different localities have different harvest dates, unrestricted movement of maize is uneconomic and consumers endeavour as far as possible to purchase within their own localities. With a limited period of production and an unlimited period of consumption, storage is essential.

Storage is an economic matter. The value of maize is lowest at harvest time, and increases according to the available stocks up to the time of the next harvest. The aim in storage is to have maize available when needed, in the condition in which it was put in store. Loss in value due to deterioration in quality or reduction in weight should be reckoned on the basis of the value of the maize at the time it is used, not when harvested. All three groups of people dealing with maize are concerned—or should be—with storage:—

The farmer who by efficient storage can hold his crop until market conditions are favourable, and keep that part which he retains for stock feed without loss;

The dealer, the professional storer, to whom losses during storage are a matter of financial concern;

The consumer, whether employer of labour or stock raiser, who can lower his costs by efficient storage of maize purchased soon after harvest and utilized when market prices are high.

Causes of Loss during Storage

Maize deteriorates when kept as a result of three main causes:—

(1) Sweating.

(2) Rat damage.

(3) Insect damage.

These factors react one with the other, as do most things in nature, so that the division is not absolute. A comprehensive storage scheme copes with them all.

Maize that has not been subjected to extreme heat or kept for a long time is alive and therefore breathes. This breathing is normally a very slow and practically negligible process, but it increases greatly with a slight increase in the moisture content of the grain. One of the products of breathing is water vapour, so that in a closed container, the dampness tends to increase, which stimulates further respiration, and so on until chemical changes resulting in sourness are produced in the grain and moulds infect the whole mass. On ripening, maize adjusts its moisture content to between 20 and 24 per cent by weight. Stooked in the field in dry weather, hung on racks, or heaped in cribs, it dries rapidly. In one series of observations maize was harvested with 22 per cent moisture, which after 25 days in the cribs dropped to 16 per cent. It was shelled, heaped in an airy barn and after 25 days there had dried to 14 per cent moisture content. The rate of drying depends on the humidity of the air, and should the air become damper after the maize has dried, then the maize will absorb water again. Drying becomes slower as the point of equilibrium is reached, so that the drier the maize gets the harder it is to reduce the remaining moisture. This is shown in Fig. 1, which records how a sample of 11.5 per cent moisture, brought to 20 per cent by damping and then allowed to dry in the laboratory, took 31 days to return to its original moisture content. When samples of maize of uniform moisture content were kept in atmospheres of controlled humidity, it was found that they reached equilibrium in from 30 to 36 days, drying or becoming damper as the case might be, as in the graph already given. The moisture content of each treatment after 36 days was as follows:—

Treatment	Final Moisture Content per cent
Control—exposed to air	11.5
Relative humidity— per cent	
100	20
80	13
20	5.5
0	4.5

When maize comes in contact with water, as opposed to water vapour, the moisture content of the grain rises almost immediately to the maximum. This is of great practical importance as indicating the necessity for complete protection of maize from rain. There is a second point, not so obvious, the danger of moisture condensation in closed metal tanks exposed to extremes of temperature. Any moisture produced in a metal tank filled with grain not quite dry will be vaporized during the heat of the day, re-condensed during the night on the cooled metal and then run down towards the bottom of the tank until absorbed by the maize. Thus a layer of mouldy grain is produced in the bottom of metal tanks. A similar result is obtained in tanks constructed with an inner face or floor of impervious cement from which the maize is not separated

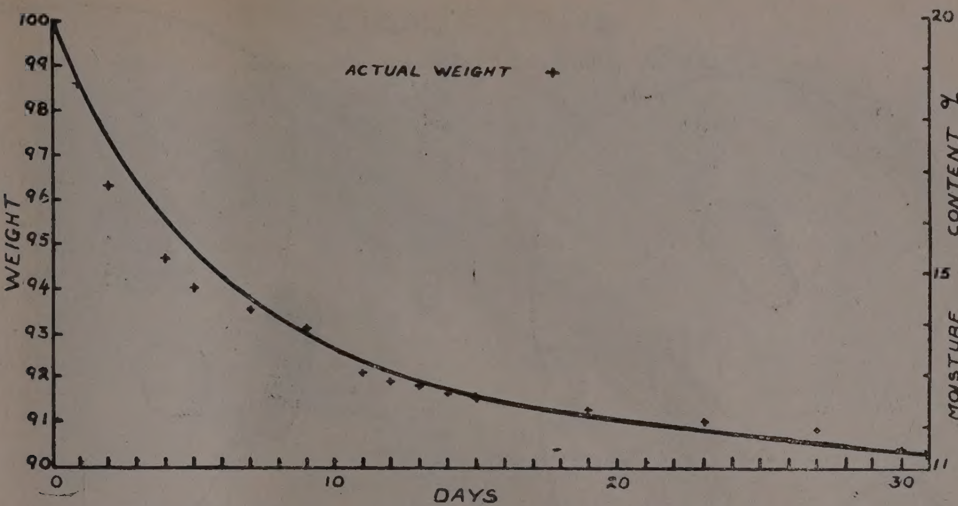

FIG. 1.—Graph showing the rate of drying of maize of 20 per cent moisture content on exposure to the air.

by some absorbent or insulating material. Maize in bags stacked in contact with cement floors deteriorates in a similar manner if not absolutely dry.

Reasonably well dried maize exposed to the air in ordinary storage will gradually reach a stage of dryness that depends on the local climate (i.e. relative humidity of the air). Samples examined from three localities in Tanganyika, all during the dry season, gave the following ranges of moisture content:—

Morogoro, coastal plain: 10.9–12.6 per cent.
Dodoma, central plateau: 9.2–9.6 per cent.
Iringa, Southern Highlands: 11.8–14.5 per cent.

At Mombasa maize for export is conditioned to 13 per cent as being the maximum for storage safe from all points of view. It would appear that this figure is not always obtainable in producing areas in the Kenya Highlands owing to the damp climate. In Southern Rhodesia 8 per cent is not unusual.

Seed maize benefits greatly by being stored as dry as possible, Mossop (*Dept. Agr. S. Rhodesia Bull.* 1161, 1940) gives the following results of germination tests on samples of maize maintained under constant specified moisture contents for three years:—

Moisture Content per cent	Germination per cent
Three below 9.6	96–100
One at 9.6	88
One at 13.6	12

A possible explanation of the failure of maize seed to germinate after being stored in metal bins, and usually blamed on carbon-bisulphide fumigation, may lie here.

Dry maize stored in sealed bins or tanks is more or less immune to subsequent climatic changes. Thus maize harvested in the dry season and stored in a proper bin after drying to not less than 13 per cent moisture content runs no risk of deterioration in the wet season; not so, however, if maize is in the crib, or bagged and exposed to the air.

Rodents are partial to maize. They feed on the cobs in the field and, when allowed to do so, follow the crop to the drying racks, cribs and store. The most consistent offender is the common house rat, but the grey field mouse, in years of large numbers, will enter stack-yard and barn in search of food as the fields become bare after harvest. In captivity a single young adult house rat will eat one-third of an ounce of maize a day and damage more, while an adult field mouse has been found to eat up to half an ounce. Apart from the actual loss of weight resulting from the nightly feeding of large numbers of rats and mice, the damaged grains are left in a condition most susceptible and attractive to insect pests. The fouling of maize heaps is conducive to heating and rapid development of moulds. Damage to sacks by rats is especially important these days. Drying racks and cribs can be protected from rats if their floors are three clear feet from the ground, on timber or masonry supports that carry circular or rectangular metal sheets projecting not less than four inches all

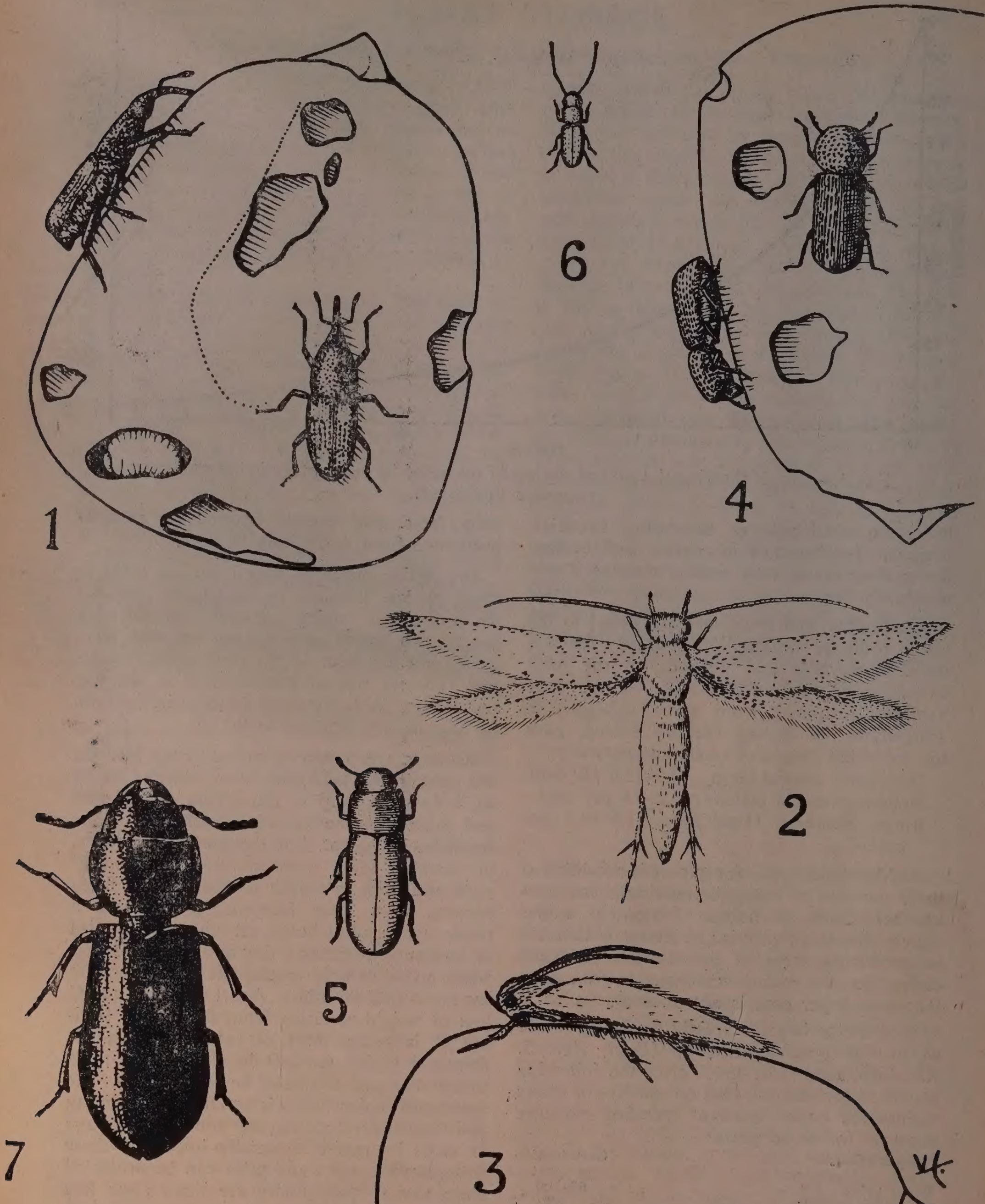

FIG. 2.—Insect pests of maize in storage.

1. Maize weevils, adults and a grub.
2. Grain moth.
3. Grain moth laying egg on maize.
4. Lesser grain-borers.
5. Red flour-beetle.
6. Flat grain-beetle.
7. Cadelle beetle.

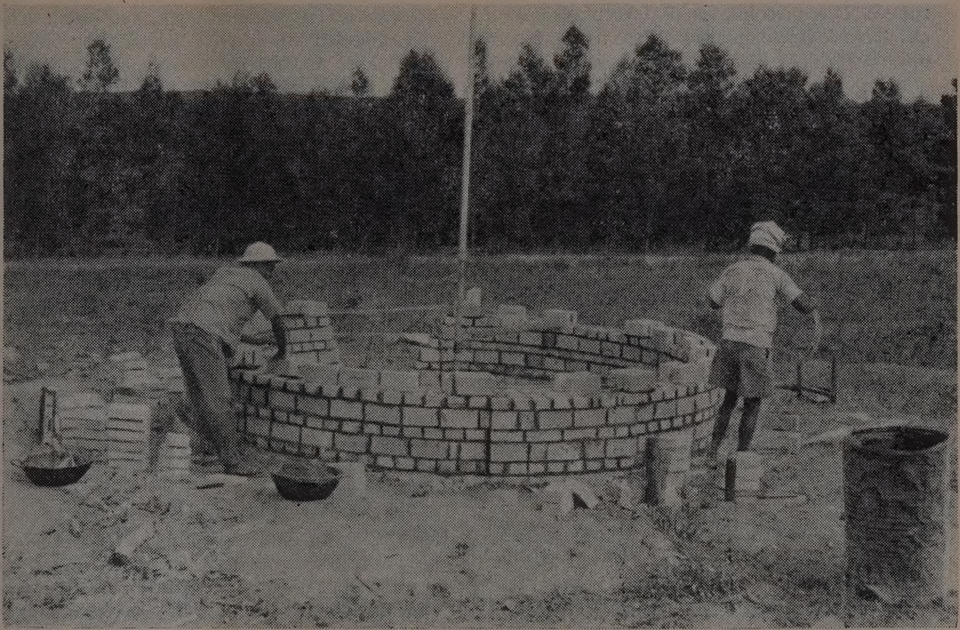

PLATE 1.—Maize bin of reinforced burnt brick under construction. Reinforcing wire being laid in appropriate course. Sweep used by mason to obtain true circle can be seen.

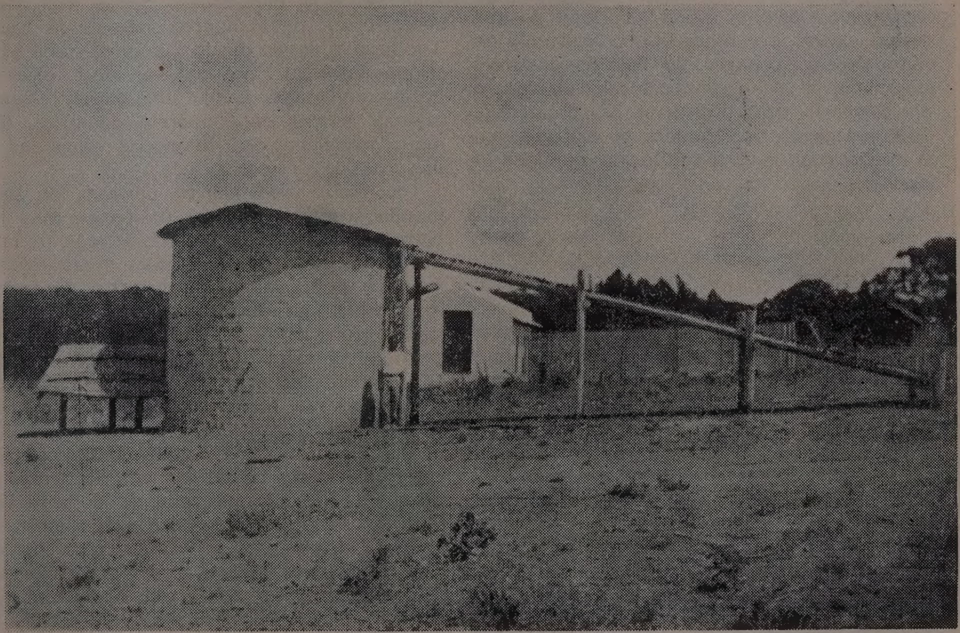

PLATE 2.—Maize bin, 30 ton size, at the Iheme Experimental Farm, Iringa, with loading ramp and bagging pit.

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round. The principle is that employed in the circular rat-shields placed on the mooring ropes of ships in dock. Stores other than sealed tanks and bins are protected by building into the outer wall a sheet of metal projecting four inches all the way round. All doorways should open above the metal shield, and there must be no permanent steps. Rainwater pipes require to have shields fitted. Finally, no unprotected buildings or overhanging trees should come within three feet of the rat-proofed store or crib.

The following are the more common insects (see Fig. 2) associated with maize stored as grain:—

Maize weevil (*Calandra oryzae*).
Grain moth (*Sitotroga cerealella*).
Cadelle beetle (*Tenebrioides mauritanicus*).
Flat grain-beetle (*Laemophloeus minutus*).
Red flour-beetle (*Tribolium confusum* and *T. castaneum*).
Lesser grain-borer (*Rhizopertha dominica*).

These are all insects widely distributed throughout the tropics. There are one or two most injurious pests of stored grains which are as yet unknown to East Africa.

Of the insects listed above, only maize weevil and grain moth are to be regarded as primary pests of stored maize. They alone are capable of attacking sound, dry grain to any serious extent. The other insects feed only on grain already damaged, so that the numbers present in a sample indicate the degree to which weevil and moth attack has progressed. This is seen in two samples of maize which in examination gave the following numbers of insects:—

	A	B
Maize weevil	106	202
Flat grain-beetle	6	81
Red flour-beetle	5	6
Lesser grain-borer	1	–
Grain-moth grubs	6	–
Cadelle-beetle grubs	–	6

In addition to these insects one finds minute wasps and bugs which feed on the weevil grubs, tiny "book lice" attracted to the sweating, broken grains, and, as an indication of rat visitors, fleas.

The caterpillars of the grain moth hatch out of eggs laid on the surface of the grain and bore straight into the grain. There they feed until the time comes to pupate, after which the moths of the new generation emerge from their shelter to fly off and infest other grains. Not only are the grains reduced in weight and the door opened to the secondary insects to add to the damage, but destruction of the germ reduces the germinating power of the grain and its food value. Badly infested grain becomes a useless mass of husks and insect debris.

The grain moth is a small grey insect a quarter of an inch long when at rest with its wings together. It usually lays from 40 to 100 eggs, which hatch in a week or less, depending on the temperature. The caterpillar feeds for about three weeks, reaching the size of one-quarter of an inch before turning into a pupa. The next generation emerges and begins to lay eggs again five weeks after it was itself an egg. Grain-moth damage is done mainly to corn on the cob, especially when stored in a crib after husking. A cob with a tightly fitting husk, without tip extrusion or rat damage, is safe from attack. After shelling, only the top six to nine inches of a heap of maize is infested by grain moth as it is not able to penetrate any deeper into the mass of closely packed grains, but this layer is liable to sweat and so attract weevil and the secondary pests, thus opening the way to further destruction. Damage by grain moth can be avoided by drying the cobs rapidly, shelling early, and storing the grain in bags or covered bins. Grain which is to be kept on the cob should be well covered with the husk. Grain moths maintain themselves in rat-holes, old sacks, and places where odd grains accumulate.

The maize weevil is one eighth of an inch long. It is a dark-brown beetle with four characteristic light-coloured spots on its back. The head is drawn out to a pointed snout with strong jaws at the end—a most efficient boring apparatus. Unlike the closely related granary weevil of temperate countries, the maize weevil has well developed wings and it flies.

The maize weevil lives upwards of four months, during which time the female may lay between 300 and 400 eggs. These eggs are laid inside the grain in small holes bored by the female with her snout, and then they are sealed over with a gum which dries hard. Small, white, legless grubs hatch out and feed on the grain surrounding them until they change into the adult weevil and then emerge into the outside world. The rate of development of the maize-weevil from egg to adult, and also the activity of the female in moving about and laying her eggs, are closely bound up with air temperature and the moisture content of the grain. Weevils cannot live on maize with a moisture content as low as 8 per cent. Up to 10 per cent the activity is slight if any. Above 10 per cent attraction to weevils and the rate of development of weevil grubs increase rapidly to a maximum at 17 per cent. At a temperature of 82°F. weevils are most active, and development is quickest, so that they can increase 700-

fold in sixteen weeks. At lower temperatures, activity is gradually slowed down, and the weevils become more and more lethargic. Nevertheless, of 250 adult weevils kept at a temperature just below freezing point, 52 per cent survived for two days and four per cent for five days. When screen temperatures show maxima and minima around 70° and 45° respectively, weevil activity is slight, but a pile of grain allowed to heat would nullify the favourable effect of such an external climate. Above 82° the effect of increased temperatures is more drastic than that produced by low temperatures, and a few minutes at 125° will kill the weevil in all its stages.

Briefly, then, the best protection against weevils is to reduce the moisture content of the maize below 9 per cent. If this is climatically impossible, as it usually is during the rains, and if temperatures do not keep well below 70°, it is necessary to keep maize out of reach of weevils if damage is to be avoided. The conditioning of maize by controlled heating reduces the moisture content and kills off all the weevils present, but the effect wears off if the maize is allowed to come into contact with moister air and so become attractive again to weevils. Proper storage is essential to preserve the maize in good condition.

Notes on the Construction of Maize Stores

Size.—A cubic foot of dry maize seed weighs 47 lb. A ton of maize occupies a space of 47.5 cubic feet. A rectangular bin with a floor space of six feet by eight feet will contain one ton of maize for each foot of its height. The following table will assist in estimating the capacity of tanks and silos of circular cross-section.

Diameter	Weight of maize per foot of height		Height required to hold one ton	
Feet	*Lb.*	*Bags*	*Ft.*	*ins.*
1	38	—		—
2	145	—		—
3	335	—	6	8
4	600	3	3	9
5	930	4½	2	5
6	1,340	6½	1	8
7	1,800	9	1	3
8	2,400	12		11½
9	3,000	15		8½
10	3,700	18		7¼
11	4,500	22		6
12	5,300	26		5
13	6,200	31		4¼
14	7,200	36		3¾
15	8,300	41		3¼

In practice an extra foot should be added to the height calculated to produce the required capacity as it is impossible to fill the bin completely from a manhole. Thus a bin 11 ft. in diameter and 13 ft. high would hold approximately 264 bags (i.e. 22 x 12)

Owing to the large volume occupied by the cob, maize is shelled before storge in bulk. A space of one cubic foot will contain 47 lb. of maize as grain, but only 30 lb. if on the cob. Unless stored in a well-designed crib in a dry climate, maize on the cob requires to be protected by a close-fitting husk if it is to remain undamaged by weevil or moth. Shelled maize is kept in one of three ways:—

(1) In heaps.

(2) In bags, stacked.

(3) In tanks, bins or silos.

Space is usually the difficulty, and except for temporary storage under tarpaulins, proper floors and roofs are equally essential in all three methods. Only in wall strength does a silo differ in its requirements from a store suitable for holding bags or grain in a heap. A heap of grain is limited in height unless pressure on the walls is allowable. Stacks of maize in bags can be carried to a much greater height but require skill and eventually mechanical equipment in handling. Silos take the greatest amount of grain for the same area of floor and roof. Of the total volume of space required, that is, the product of the floor area and the vertical height, a heap of maize works out at approximately 24 lb. per cubic foot, a stack of bags at 25 lb. and bulk maize in a silo at 47 lb.

Maize stored in heaps is wasteful of floor space, once it has become dry enough to place in a bin or silo. It offers maximum facilities for attack by weevil and grain moth. The large area exposed to the air makes for rapid increase in moisture-content in humid weather, with the result that sweating is a great danger. This danger is intensified by cement floors, and wooden floors are advisable, ventilated below if possible.

Stacks of maize in bags should be built up regularly to permit of the free passage of air throughout the mass, to reduce the risk of sweating as a result of insect attack or high moisture-content. The covering of floors with dunnage is advisable. Given initially dry maize free from insects, bagged in clean, undamaged sacks, and placed in a building which has been previously disinfected in a thorough manner, including the removal of old grain from rat holes, storage with only slight loss is possible for a number of months. Once the rains start, however, the chances of weevil infestation increase rapidly. Good sacks offer useful protection against moth, and even weevils are discouraged until pressure of numbers forces them past the barrier. The great disadvantage of this method of storing, apart from loss by insect damage, is the cost of the bags not only the temporary locking-up of their capital value,

but also the actual loss by depreciation. This should be borne in mind when calculating storage costs, particularly in connexion with the apparently higher cost of erecting masonry silos.

The storage of dry, insect-free maize in sealed bins, tanks or silos, is the only method by which one can confidently expect to keep it in good condition and without loss for any reasonable period. A well-constructed tank will pay for itself in a few years. The method of construction depends on the materials available and the size of the tank, which, in turn, depends on the amount of grain to be stored. Quantities of grain up to about 10 tons can be kept in rectangular brick bins, especially when a number of such quantities have to be stored separately, as on a seed farm, but where the amount is greater it is more usual to construct tanks, circular in section, of masonry, reinforced brick, concrete or corrugated iron. In all cases it is desirable for the foundations to be damp-proof and impervious to white ants, the walls and top reasonably airtight, and the roof waterproof and large enough to give the walls some protection from the weather.

The larger the grain store the more difficult is its construction because of the great strains which the walls must withstand. Not only is it easier to build a number of smaller stores, but, where maize is stored for consumption, it is more convenient to have tanks that are opened as required without exposing all the stock to infestation by weevil. Rectangular bins are suited to this purpose, especially where an existing building is available for converting. For example, a series of eight bins were constructed on the open verandah of a large go-down to hold maize for labour rations. Utilizing the existing masonry floor and the protection of the corrugated roof, the available space was filled with a block of six bins, each with a 5 ft. x 9 ft. floor and 7 ft. high, made of nine-inch burnt bricks with mud mortar. The tops of the bins were covered with a layer of concrete on old corrugated iron, each being fitted with a 2 x 2½ ft. manhole. The walls were finished off inside and out with a thin cement plaster. A sealed outlet-pipe was fitted to the bottom of each compartment along the outer wall and enough earth removed below the outlet to allow for bagging. In practice it was found that each compartment held about 60 bags of maize. In this type of bin a covering of roofing-felt on the floor would be advantageous, and for larger tanks some type of reinforcement would be advisable to avoid the risk of the walls cracking.

For details of the construction of reinforced brick grain bins circular in section and with capacities of from 200 to 900 bags, reference should be made to the article "Grain Storage Bins" *Rhodesian Agricultural Journal* XXXIX, No. 5 (reprinted in this issue) or to the plans and specifications of "*Farm Maize Bins*" sold by the Kenya Farmers' Association, Nakuru (price Sh. 5). Modifications to suit local conditions will be considered by the individual builder, but no saving should be attempted either with reinforcing material or mortar, as any cracking of the walls will spoil the whole scheme. External plastering of the brickwork is advisable as a protection against damp. Siting is important in avoiding trouble with damp penetrating the bottom of the bin from sub-soil water during the rains. The bin should be given ample time to dry out before grain is put in it.

A 30-ton bin during construction at the Iringa Experimental Farm is shown in plate 1. The re-inforcing wire is being laid in the appropriate course. The sweep used to assist the mason in building true is also shown. The completed bin is shown in plate 2 with loading ramp and bagging pit.

CONCLUSION

Successful grain storage is fundamentally a matter of care and cleanliness. Any of the following mistakes will lead to trouble:—

(1) Putting damp maize in a store.
(2) Putting maize in a damp store.
(3) Putting insect-infested maize in a store.
(4) Putting maize in a dirty store.

Neither the skill in farming which produces heavy yields nor the skill in building which produces estimable grain stores will add anything to the keeping properties of the maize if it is stored damp or containing insects. If there is any doubt about the dryness of the maize have a sample tested at a laboratory. If there are insects present, or, better still, just to make sure, fumigate the grain in the bin with carbon-bisulphide at the rate of 5 lb. per 1,000 cubic feet. If the grain is stacked in bags it can be fumigated under a tarpaulin, but this will not prevent re-infestation.

At the time of writing, however, carbon-bisulphide is difficult to obtain in East Africa, and alternative fumigants completely absent. Thus it is more than ever desirable to put the new season's crop into a thoroughly clean store as soon as possible. It is understood that good results are obtained in South Africa by placing a lighted candle in a completely filled maize bin before sealing up the manhole. The oxygen is used up quickly and insect activity is slowed down. This would be a useful precaution to take in any case when fumigation is impossible, but it will not obviate the necessity for taking precautions against mixing insect-infested grain with clean maize going into the store.

GRAIN STORAGE BINS*

Three designs of grain storage bins are shown in the accompanying drawings.

In normal times the circular bin with a flat reinforced concrete roof would be recommended as the most economical and satisfactory design, but since much of the reinforcing material necessary for its construction is now unobtainable two other designs are shown, in which the amount of steel and wire required has been considerably reduced, especially in that shown in Fig. 3, for which only 70 yards of suitable wire is needed.

The details of construction are clearly indicated in the drawings, but a detailed explanation of the more important constructional features is given hereunder.

Building and Reinforcing Walls

The site selected for the erection of these bins should be a well drained one where a good solid subsoil formation exists.

The foundations and walls must be set out and built in a true circle. Good, sound, well burnt bricks must be used throughout. In the reinforced bins shown in Figs. 1 and 2 the brickwork should be laid in a 1:5 cement mortar and all the bricks should be soaked in water immediately before being laid. The mortar joints on the inside of the wall should be neatly struck to give a smooth finish, and on the outside the joints should be raked out to a depth of ¾ inch to provide a good key for the plaster.

Where reinforcing wire is required the number of turns in each course or section of wall is shown in figures against the various sections.

The inner ring of bricks in each section is laid first. In the 14-inch foundations only one course is laid at a time either as "headers" or "stretchers" according to the bond of that particular course. In the 9-inch wall these courses are laid as "stretchers". When each such ring is completed the specified number of turns of wire are wound round; commencing at the top, half the total number of turns are made in a downward spiral, the remaining number of turns being made in an upward spiral so that the two ends meet and can be joined together. The outer rings of brickwork are then laid in the ordinary way, great care being taken that the joint between the inner and outer rings occupied by the wire is completely filled with mortar which may be poured in as a semi-liquid grout. Each stage of construction is shown.

The Damp Course

An effective damp and ant-proof course is essential, and while galvanized iron or damp course felt should be used if available, a substitute may have to be adopted. It is suggested that for this purpose tar or bitumen such as "Colas" may be warmed and mixed with sufficient sand, which should also be heated, to form a stiff mixture, which is applied while still hot to the brickwork at the proper level, in a layer about ⅜ inch thick. The mixture must be allowed to set for two or three days until it is sufficiently hard to permit the building to be continued.

Alternatively the course of brickwork immediately below the damp course level may be replaced by a ring 1:2:4 concrete three inches thick, the surface of which should be coated with tar or bitumen before further bricks are laid.

The Floor

An essential precaution in building any of these bins is to ensure that the floor shall be impervious to moisture and termites, it is strongly recommended that the joint between the floor and walls should be sealed with bitumen in the following manner.

Before the concrete floor is laid the inside of the foundations should be plastered with 1:4 cement plaster to a depth of eight inches below the damp course. The concrete floor is then laid with its rim slightly above the damp course, and as the concrete is laid a V-shaped groove about 1½ inches wide and of the same depth must be formed between the floor and the plastered surface of the foundations. When the concrete is dry a quantity of bitumen, which is normally solid at ordinary temperatures, is melted, preferably in a container surrounded by boiling water, and poured into the groove, which should be completely filled. In the event of the floor shrinking or subsiding the bitumen will yield sufficiently to maintain a waterproof joint, whereas otherwise a crack

* Reprinted from the *Rhodesia Agricultural Journal*, Vol. XXXIX, No. 5, 1942.

would develop. In order to ensure that the bitumen adheres to the concrete before it solidifies, it is advisable to warm the surface of the Vee groove with the flame of a blow-lamp as the bitumen is poured and the bitumen itself may be kept warm with the blow-lamp for a few moments as it flows along the groove.

It may prove difficult to determine when the bin is thoroughly dry, and as an added precaution against dampness rising from the concrete floor, it is suggested that it should be given some impervious covering. A material such as damp-proof felt, "Malthoid", or other similar floor covering should prove suitable, but failing one of these a bituminous mixture similar to that suggested for the damp course spread in a ¼-inch or ½-inch layer over the entire floor should prove equally effective.

Plastering

In the case of the flat topped bin some question arises as to whether the walls should be plastered internally or externally, since there are advantages and disadvantages in both methods of construction. In the blue prints previously issued by this Department these bins are shown plastered on the inside, but it is now considered that the advantages of external plastering predominate, and in all cases this alternative is recommended.

The brickwork should be allowed to dry out as long as possible before the plaster is applied. When plastering, the surface of the brickwork should be moistened sufficiently to ensure the proper adhesion of the plaster. The plaster should be mixed in the proportion of one part cement to four parts of clean, sharp river sand. When circumstances permit the plaster should be kept damp for a few days to prevent the development of fine cracks. When dry the plaster may be given two thin coats of limewash, which will render it more waterproof and will tend to keep the bin cooler and maintain a more even temperature. An external application of limewash is also recommended in the case of bins which have already been plastered internally.

It should be noted that when plastering the sloping roof of the conical bin the plaster should be sufficiently thick to cover the projecting corners of the bricks to a depth of half an inch.

Filling

It must be very clearly understood that the bin must be thoroughly dry throughout before being filled. The outlet pipe and the manhole should both be left open to allow as much draught as possible to pass through the bin. The process might be hastened by lowering buckets filled with burning wood or charcoal into the interior, but one must not be deceived by the superficial dryness which such a procedure might induce.

It is equally important that the maize should not contain more than 12½ per cent moisture when placed in the bin.

Caution

When the maize has been in storage for some little time it is probable that the atmosphere within the bin will contain a fairly high percentage of carbon dioxide, and great care must be exercised to see that the bin has been sufficiently ventilated before anyone enters it.

Special Notes on the Construction of the Circular Semi-reinforced Brick Bin

This design has been introduced solely to meet the needs of those who, in the present difficult circumstances, are unable to obtain the requisite amount of reinforcing wire to construct either of the bins shown in Figs. 1 and 2. Actually this structure is not theoretically sound, but if constructed strictly in accordance with the following recommendations there is little doubt that it will prove entirely satisfactory in practice.

The quantity of wire required to reinforce the walls has been reduced to a minimum and the stability of the structure depends largely on the strength of the brickwork only. It is therefore of the greatest importance that only hard, sound, uncracked bricks should be used in its construction. They must be thoroughly soaked in water immediately before being laid. Cement mortar mixed in the proportion of one part cement to four parts of clean, sharp river sand must be used throughout and great care must be taken to see that each course is properly bonded and that the vertical joints are evenly staggered. The top three courses of the vertical wall must be reinforced with six strands of wire to withstand the outward thrust of the conical roof.

On completion the bin must be allowed to dry for at least six weeks before being filled to ensure that the brickwork attains the required strength, but it is probable that a still longer period will elapse before the structure is thoroughly dry and can be filled without fear of the grain being spoilt by dampness.

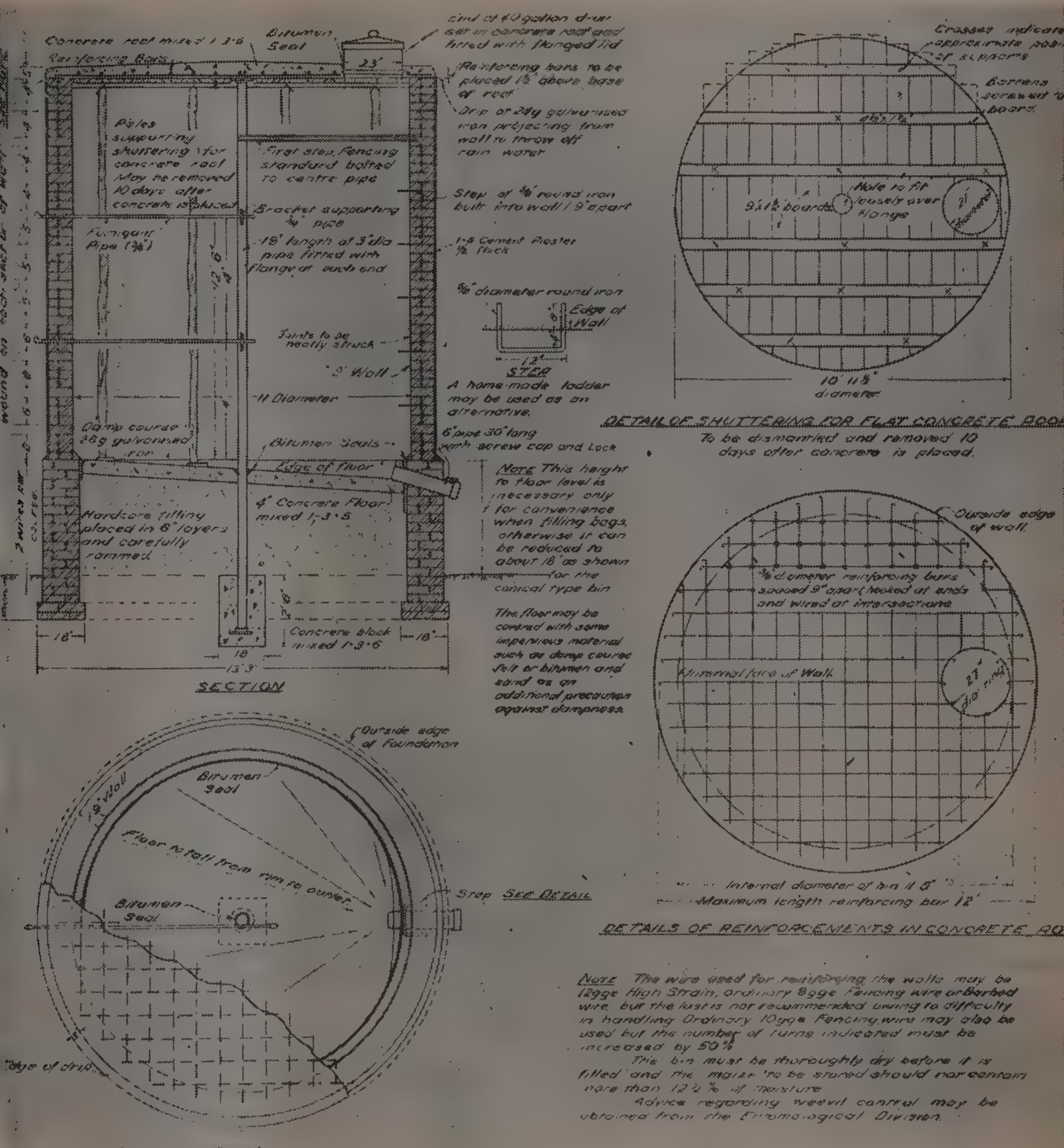


FIG. 1

CIRCULAR TYPE GRAIN BIN WITH FLAT ROOF

Capacity { 11′ Diameter × 12′ 6″ High = 250 Bags.
11′ Diameter × 10′ High = 200 Bags. }

SCHEDULE OF QUANTITIES—GRAIN BINS

Circular Type with Flat Roof—Capacity, 250 Bags

Item	Quantity	
Brickwork	Bricks	6,500
	Cement ..	25 pockets
	Sand	5 cu. yds.
Concrete floor and roof	Cement ..	17 pockets
	Sand	2 cu. yds.
	Stone	3½ cu. yds.
Plaster	Cement ..	7 pockets
	Sand	1 cu. yd.
Reinforcing wire ..	For foundations	400 yds.
	For walls ..	700 yds.
Reinforcing iron for concrete roof, ⅜ inch diameter	310 feet	
Centre pipe	3″ × 18′ with two flanges ..	1 length
Outlet pipe as shown	One	
Steps	⅝″ diameter iron	14 feet
Fumigant pipes ..	¾″ × 7′ with elbow and plug	Two
Bitumen for sealing floor	30 lb.	
Damp course and floor covering	As required	

For a bin 10 feet high having a capacity of 200 bags, the above quantities will be reduced by the following amounts :—

Bricks, 850. Cement, 3½ pockets. Wire, 175 yards.

Circular Reinforced Bin with Conical Roof. Capacity, 135 Bags

Item	Quantity	
Brickwork	Bricks	4,300
	Cement ..	18 pockets
	Sand	3½ cu. yds.
Concrete floor and roof cap	Cement ..	6 pockets
	Sand	¾ cu. yds.
	Stone	1¼ cu. yds.
Plaster	Cement ..	8 pockets
	Sand	1¼ cu. yds.
Bitumen for sealing floor	25 lb.	
Reinforcing wire ..	450 yds.	
Outlet pipe as shown..	One	
Damp course and floor covering	As required	

Circular Semi-reinforced Bin with Conical Roof Capacity, 135 Bags

Item	Quantity	
Brickwork	Bricks	6,500
	Cement ..	30 pockets
	Sand	4½ cu. yds.
Concrete floor and roof cap	Cement ..	6 pockets
	Sand	¾ cu. yds.
	Stone	1¼ cu. yds.
Plaster	Cement ..	8 pockets
	Sand	1¼ cu. yds.
Bitumen for sealing floor	25 lb.	
Reinforcing wire ..	70 yds.	
Outlet pipe as shown..	One	
Damp course and floor covering	As required	

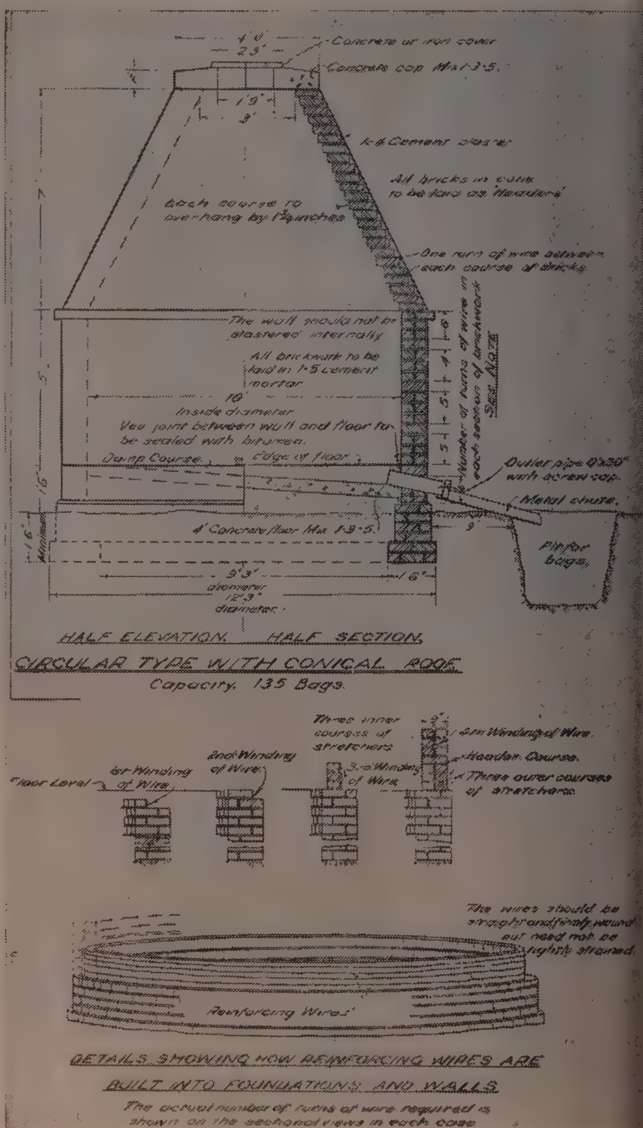


FIG. 2

CIRCULAR TYPE GRAIN BIN WITH CONICAL ROOF
Capacity 135 Bags

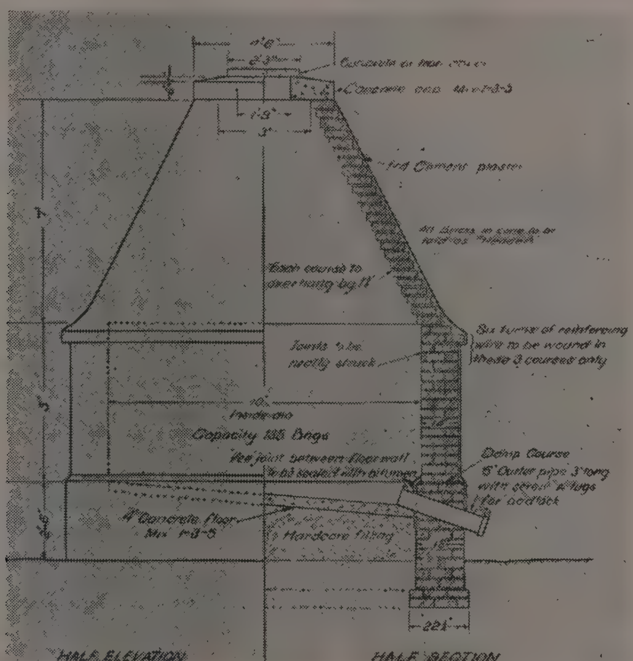
Testing for Dryness

Since it is of such great importance that these bins should be thoroughly dry before being filled, it is recommended that they should be built in the dry season, at least six weeks before the rains may be expected.

The following procedure is suggested, as a rough and ready test to indicate if the bin is dry.

When the bin appears to be dry, probably six weeks after completion, a few pieces of ordinary dry newspaper should be hung in the bin at various heights on the wall. The bin should then be sealed up for 24 hours. If, at the end of this period, the paper is found to be in the least soft or clammy, the bin should be ventilated for a further period of a few days, and the test repeated. When the paper remains dry and brittle after being sealed up in the bin for two or three days, it may be assumed that the bin is sufficiently dry.

An alternative indicator which might be used at the same time is common salt. The salt, after being thoroughly dried and powdered, should be placed in two or three open containers at different levels in the bin, and the tests made as previously described in the case of paper. The salt will tend to cake if any excessive moisture is present.



Scale: 1″—4

NOTE

Brickwork

The stability of this bin is dependent on the strength of the brickwork alone and it is essential therefore that all the bricks must be hard, sound and uncracked. They must be thoroughly soaked in water immediately before being laid. They must be laid in 1—4 cement mortar and correctly bonded so that the vertical joints are evenly staggered.

Damp Course

If suitable metal or felt is unobtainable, the damp course may consist of a 5/8 in. layer of tar or bitumen and sand applied hot, or the top course of the 18 in. foundations may be replaced by a ring of concrete 3 in. thick.

Reinforcement

The top three courses of the vertical 14 in. wall only are reinforced with six turns of wire.

The wire used may be 12½ gauge high strain, ordinary 8 gauge fencing wire or barbed wire.

The bin must be allowed to dry for at least six weeks before it is filled to ensure that the brickwork attains adequate strength. A longer period may be found necessary to ensure the complete dryness essential for the safe storage of the grain.

FIG. 3

CIRCULAR SEMI-REINFORCED BRICK GRAIN BIN

MECHANICAL COMPOSITION OF EAST AFRICAN SOILS

By G. Milne and W. E. Calton,* East African Agricultural Research Station, Amani

The object of the present paper is to review some of the data on East African soils which have accumulated at Amani in the past few years. The soils discussed include type samples collected on various traverses and reconnaissances, the study of which led to the production of a Provisional Soil Map of East Africa in 1935. The memoir accompanying this map indicated that detailed accounts of the main soil types would be published later. For various reasons it had not been possible to do this, except incidentally in reports and papers mainly of local interest, and now, following the tragically sudden death of the senior author, much knowledge of East African soils is lost. In this, and subsequent papers which are projected, it is hoped to show some of the basic properties of East African soils and the lines along which soil investigation was developing.

Mechanical analyses were done by the standard international method [1] with soda dispersion, though in some cases ammonia was used with satisfactory results. Organic matter was oxidized by hydrogen peroxide or hyperol. Occasionally sodium hypobromite was used and this was found to give results agreeing well with the former reagents. Manganese dioxide was removed from soils rich in this constituent by sulphur dioxide before hydrogen peroxide treatment. Data on clay contents obtained by the pipette method were in many cases duplicated by sedimentation. It was possible to train African assistants to do much of the manipulation, but weighing operations were retained in our own hands. Mechanical analyses done at Amani agreed satisfactorily with Prof. G. W. Robinson's results on samples submitted to him.

The grading of fractions throughout is (by particle size):—

Coarse sand—0.2 — 2.0 m.m.
Fine sand—0.02 — 0.2 m.m.
Silt—0.002 — 0.02 m.m.
Clay— $<$ 0.002 m.m.

The results are oven-dry fractions expressed as a percentage of air-dry sample; air-dry moisture and loss by solution are not given, being in the main unimportant and irrelevant to the present discussion. The profiles reported are mainly non-calcareous, but where calcium carbonate occurs it is noted or its amount given.

A peculiarity of East African and possibly other tropical soils is that no consistent relation is found between mechanical composition and field properties. Friable and non-friable tropical soils have been pointed out before [2] and this difference has been related to clay composition. More recently [3] certain soils in Australia, where soils with tropical affinities occur, have been found to have a mechanical composition differing from their texture estimated in the field. Prof. J. A. Prescott states that it was not that the judgment of the surveyors was at fault but that some difference in the character of the clay was probably responsible. Engineers [4] [5] in America and South Africa evidently recognize different mechanical types of clay, because in building stable earth roads they specify, in addition to definite proportions of clay, silt and sands, limiting plasticity values. Milne [6] has shown that soils of similar mechanical composition may have very different field properties, for example, the soils bracketed together below, which occur within a short distance of each other on similar parent material.

No.	Locality	Coarse Sand	Fine Sand	Silt	Clay	Field Properties
1998	Kasela	49·0	14·5	1·4	30·4	Almost untillable dry, water logging when wet.
1984	Kange	47·5	18·3	1·7	31·3	Friable and free working over wide range of moisture content.
600	Baga	23·8	19·7	13·4	37·0	Strong sandy clay of considerable tenacity.
931	Sangerawe	24·4	21·6	11·3	34·5	Friable and free working over a wide range of moisture content.
418	Tengeni	27·0	14·2	3·3	52·0	Almost untillable dry, water logging when wet.
2236	Mlingano	29·6	11·3	3·6	54·5	Friable and free working over a wide range of moisture content.
11	Uplands	0·1	3·5	6·5	75·7	Almost untillable dry, water logging when wet.
1418	Kiambu	1·6	3·7	10·5	75·8	Friable and free working over a wide range of moisture content.

* The actual writing of this paper is due to Mr. Calton.—*Ed.*

The range of clay content over which this difference in clayeyness occurs is very wide and it is obvious that judgment of mechanical composition based on touch would be quite erroneous. It is impossible to exclude either the friable or non-friable soils as unimportant or atypical and this is especially so in irregular country where a rapid succession of friable, intermediate and tenacious soils is commonly found. The idea of a catena or topographic sequence of soils was evolved to meet this difficulty. The catena has come more and more to be considered as a unit for study.

The following triangular diagrams bring out the divergence between estimated texture and mechanical composition of East African soils.

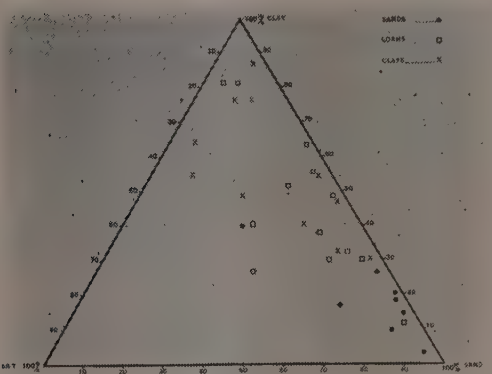


FIG. 1

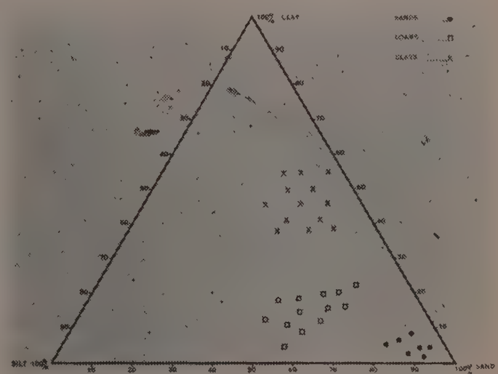


FIG. 2

The 32 soils plotted are taken at random from 28 widely separated profiles and do not include more than two horizons from any one profile. Where two samples are taken from one profile each has a different texture. These triangular diagrams are constructed as follows. Coarse and fine sand are added together and the sum of sand silt and clay recalculated to 100; the value of each constituent is plotted on the appropriate side of the triangle and a line drawn from this point parallel with the zero line for that constituent. The three lines intersect at a certain point within the triangle. The position of this point in relation to the corners of the triangle enables the proportions of the three constituents to be quickly appreciated.

Except for extreme sands the field character of East African soils appears to be dominated by clay quality. We have come to recognize three groups of clays—siliceous clays, kaolinite-type clays and sesquioxidic clays—which form as it were a degenerating series through progressive loss of silica and decreasing colloidality. This range of clay types results from the variation in degree of leaching, which may be intense, and in age of parent material. It is suggested that the correlation between mechanical composition and field properties found in countries of temperate climate results from the existence of a more or less uniform clay complex possibly predominantly of a beidellite type. The absence in those regions of intense leaching and the frequent youthfulness of parent material supports this argument.

Apart from its influence on field properties, clay (i.e. material $<$ 0.002 mm.) is of interest as being the reactive part of the soil and its development and distribution in the profile is worth discussion.

An extreme soil type derived from marine sediments is found along the East African coast, as for example, from Bagamoyo:—

	Coarse sand	Fine sand	Silt	Clay	
549– 0-12″	85·7	7·9	0·6	4·2	Dark grey coarse sand.
550–12-24″	76·3	17·8	1·6	3·2	Grey coarse sand.

These two samples are composites from a number of scattered points. The remainder of the profiles reported in this paper each come from a single site and the various profile layers can be directly compared.

A profile from Zanzibar, also on marine sediments, shows unusual variability with depth:—

MAZINGINI

	Coarse sand	Fine sand	Silt	Clay	
671–0-6″	49·6	22·2	2·8	23·2	Friable brown soil.
Layer 672-2nd	28·3	18·3	3·4	48·9	Mottled yellow and reddish-brown.
673-3rd	41·0	31·2	18·0	7·2	Creamy-yellow fine sand.
674–4th	26·9	37·2	19·2	11·9	Pinkish fine sand.
675–5th	7·2	5·6	7·8	71·0	Bluish-grey clay.
676–6th	61·2	16·5	3·1	19·1	Greenish-grey sand.

The lower layers of this profile probably have little effect on soil processes and are regarded as C. horizons.

Fluviatile sediments show less marked profile changes:—

MOROGORO

	Coarse sand	Fine sand	Silt	Clay	
834-0-4″	27·6	26·7	12·2	28·4	Grey-black friable top soil with mica flakes.
835-4-7	25·1	26·9	11·0	31·3	Grey-black cloddy subsoil.
836-10-11	36·8	25·8	8·6	26·5	Similar.
837-15-17	21·6	29·3	9·5	35·2	Browner.
838-24-27	20·8	37·2	8·2	32·3	Similar, with dark brown and grey mottling.
839-36-39	58·4	24·8	2·5	14·9	Dark-brown sand with rounded rock fragments and black concretions.

A further source of profile irregularity is stratification of parent material:—

SHIWANDA

	Coarse sand	Fine sand	Silt	Clay	
1837/8-0-9″	10·8	18·9	18·7	44·8	Humic topsoil.
1839/40-12-30	5·7	12·8	15·5	58·9	Reddish-brown clayey subsoil.
1841-30-42 ..	6·6	20·3	27·0	35·1	Yellow-brown sand.
1842-42-57 ..	5·0	15·1	20·2	50·7	Darker coloured.
1844-72-78 ..	10·6	20·2	14·8	52·1	Red and brown mottled clay.

The 30–42 in. layer clearly originated as a rock stratum and not as a soil horizon.

A double soil, as it were, occurs near Mt. Rungwe, where volcanic ejectmenta, mainly pumice, have actually buried a mature soil and a new soil has formed on the superficial material, for example:—

CHIWANJE

	Coarse sand	Fine sand	Silt	Clay	
1141-0-6″	9·9	24·6	30·7	25·4	Brown friable topsoil.
1142-6-18	11·1	19·0	20·2	38·6	Red-brown stiffer subsoil.
1143-At 36	3·2	7·3	11·9	70·5	Bright red-brown clay.
1144-At 60	2·5	7·5	11·2	72·5	Similar.

The line of demarcation is at about 2 ft. There are big differences between the two soils. If, as seems likely, parent material is the same in each case, the coarse sand appears to break down to finer fractions at a greater rate than fine sand or silt and finally practically disappears. There is, however, no information on the chemical composition of the coarser grades and on whether any of them can be considered secondary in origin. By analogy with the advanced gneiss profile quoted below, some of the silt fraction of the lower half of the profile might be found to be secondary.

Apart from the profiles mentioned above, only gradual changes usually occur with depth. A maturity sequence on volcanic parent material, where maturity is estimated from age combined with leaching intensity, is illustrated by the following profiles. A young greyish soil derived from recent powdery volcanic material has the following composition:—

ENGARE OL MOTONYI

	Coarse sand	Fine sand	Silt	Clay	
689-0-12″	6·2	31·5	25·2	27·5	Light grey, dusty, very friable.
690-12-48	6·9	29·8	24·7	29·5	Grey, friable.
691-48-72	6·3	27·2	21·4	35·2	Brownish-grey, friable.

An adjacent soil of similar origin but subject to greater leaching shows:

TENGERU

	Coarse sand	Fine sand	Silt	Clay	
1445-0-6″ ..	4·1	17·6	17·8	40·8	Dark brownish-grey clay loam with little variation throughout profile.
1446-6-12 ..	4·8	18·9	19·9	41·3	
1447-12-18	3·4	19·7	20·3	45·5	
1452/3-42-54	2·4	16·7	16·5	51·8	
1456-66-72	3·3	16·3	18·1	51·1	

There are marked differences in clay quantity and possibly clay quality between these two profiles. The increase in clay content at the expense of the coarser grades is evident. An older soil closely comparable genetically has the following composition:—

OLDEANI

	Coarse sand	Fine sand	Silt	Clay	
3900-0-6″ ..	1·6	8·4	22·2	57·6	Crumbly, dark chocolate topsoil.
3901-6-12 ..	0·6	5·2	13·6	72·8	Chocolate-coloured stiff subsoil.
3902/4-12-36	0·6	4·4	11·4	76·3	Similar.
3907-60-72	0·6	3·0	7·8	84·4	Similar, slightly brittle.
3910-132-144	0·7	3·9	13·1	74·8	Similar, with black concretions.

These data suggest that volcanic material, containing no discrete particles of resistant minerals, may weather ultimately entirely to clay. Full development could doubtless be delayed or even prevented by aridity, impeded drainage, denudation, etc., and the formation of secondary coarse fractions seems possible.

A similar maturity sequence on soils derived from crystalline rocks is difficult to illustrate because immature soils on these parent materials are relatively rare. A soil forming in rock crevices on a granite hillock has the following composition:—

KAHAMA

	Coarse sand	Fine sand	Silt	Clay	
3028	50·3	24·2	5·4	16·6	Dark-coloured gritty loam.

A more developed granite profile shows:—

MANYONI

	Coarse sand	Fine sand	Silt	Clay	
2891-0-8″	55·2	30·4	3·4	12·6	Grey-brown gritty loam.
2892-8-14	47·5	34·5	3·4	16·1	Transitional to.
2894-20-30	48·0	30·0	3·1	20·1	Orange-brown subsoil.
2896-40-50	51·7	26·3	3·4	20·2	Yellowish slightly cohering sand.
2898-66-76	48·3	26·3	5·2	21·9	Yellowish-brown with maroon concretions.

This soil is not subject to intense leaching, the concretionary material indicating conditions suitable for the precipitation of iron rather than the advanced breakdown of clay complex. A highly leached granite soil (mol. SiO_2/R_2O_3 ratio of clay fraction about 1.0) has the following composition:—

LUPEMBE

	Coarse sand	Fine sand	Silt	Clay	
1804 0-6″	28·7	9·1	5·1	42·7	Grey-black organic topsoil.
1805 8-12	33·3	7·0	5·0	44·9	Transitional to.
1806 15-20	35·3	6·8	3·6	49·7	Yellowish-grey sandy loam suggesting a bleached zone.
1808 33-40	32·4	7·8	3·5	53·4	Yellowish-brown sandy loam.
1810 60+	30·3	11·7	17·9	38·4	Decomposed granite–pink sandy clay.

The development of granite soils therefore seems to be towards increasing clay content with a reduction in the coarser fractions, especially those intermediate between clay and the resistant coarse-grained quartz of the parent material. Silt contents are low compared with those in soils derived from alluvium or volcanic rocks and this appears to be a fairly general characteristic of sedentary soils on crystalline rocks. The weathering of felspathic constituents in a coarse-grained rock is probably a relatively rapid chemical process under tropical conditions and the absence of frost and abrupt temperature changes possibly helps to account for the weak development of silt. The siltiness of alluvial soils is possibly largely due to abrasion, while some at least of the volcanic soils start life as finely divided rock. Moderate siltiness is often associated with considerable fertility, suggesting that silt supplies weatherable mineral reserves. Typical mechanical analyses, given by Emerson, [7] of eleven classes of American soils ranging from sands to clays presumably more fertile than leached tropical soils, show in ten of them silt largely exceeding clay.

Figure 3 illustrates the progressive changes in mechanical composition under increasing leaching on volcanic and granitic parent material. The numbers represent, in order, increasing development.

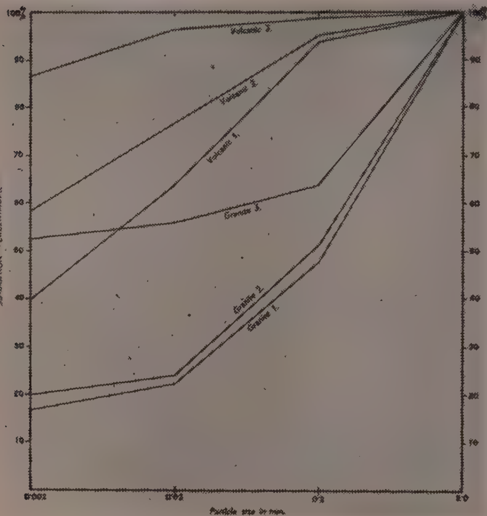


FIG. 3

The following red-earth profile derived from gneiss shows very low silt contents:—

MLINGANO

	Coarse sand	Fine sand	Silt	Clay	
2221 0-6″	31·7	11·2	2·4	54·3	Bright red loam with little change with depth.
2222 6-12	27·8	9·5	2·2	59·5	
2223 12-22	25·7	8·4	2·1	64·1	
2225 32-40	24·7	8·2	2·1	64·8	
2227 64-72	20·3	8·8	3·2	67·7	

This profile appears to consist almost entirely of clay and quartz. What might be considered as a further stage in the development of sedentary soils on crystalline parent material is illustrated by the following profile:—

MSHITUNI

	Coarse sand	Fine sand	Silt	Clay	
1976 0-6″	18·8	15·2	11·4	50·9	Greyish orange brown loam.
1977 6-14	20·2	13·5	11·6	52·8	Similar, a little redder.
1978 14-20	20·3	14·6	11·3	53·9	Similar.
1979 20-27	17·9	15·0	12·5	54·6	
1981 40-52	17·2	13·4	9·7	60·5	Similar, with rotten gneiss rock partly gibbsitic.

The silt and part of the fine sand fraction of this profile consist of iron and aluminium hydroxides, which are probably residual from the breakdown of the clay complex. The clay fraction itself has a mol. SiO_2/R_2O_3 ratio of less than 1. Parent material or at least floating rock fragments appear under the present exhausted conditions to be weathering directly to sesquioxides. The resilication of the gibbsitic rock brash, which could be regarded as equivalent to Harrison's primary laterite [8] is very hard to envisage. Intense leaching and hilly topography are probably essential conditions for the development of this very advanced type.

The general trend of development in leached types is therefore a progressive breakdown of weatherable minerals to clay substance with, in many soils, the virtual disappearance of material intermediate between clay and sand. Concurrently, clay alters from sticky siliceous material to friable sesquioxidic material with, in some cases, development in situ of sesquioxides in particles of silt size or larger. Under less thorough leaching, i.e. towards the bottom of a catena, this development appears to be retarded, especially in regard to the alteration of clay substance, which may even become enriched in silica. There may be other factors connected with sluggish drainage which affect the physical properties of clay. In regions where drainage is actively cutting down to a new base-line low-level soils may be much younger than high-level. As a result of these possibilities the top member of a catena may develop a greater clay fraction than the bottom member and yet be less clayey in character.

It should be added that illuvial ironstone, or murram, which is equivalent to Buchanan's original laterite and also Pendleton's Thailand laterite, [9] may occur at mid- or bottom-catena sites. By change of drainage it may become exposed as a surface layer, but it cannot be considered a normal development in thoroughly leached soils. Murrum soils in fact contain some of the decomposition products of their own and other soils.

Two soils from Muhesa illustrate differences due to catenary position:—

MUHESA RED SOIL

	Coarse sand	Fine sand	Silt	Clay	
290 0-5″	15·2	14·9	17·9	47·1	Reddish chocolate clay loam.
291 12-18	11·4	10·0	12·8	62·4	Bright red clay loam.

MUHESA BLACK SOIL

	Coarse sand	Fine sand	Silt	Clay	
282 0-4″	27·4	32·2	11·8	22·4	Sticky black clay.
283 4-8	26·3	28·9	9·8	29·4	Mottled transition.
284 23-32	14·5	30·5	8·6	41·9	Yellow clay.

The higher-lying red soil, though actually having developed more clay fraction, is less sticky than the black soil.

A catena, which covers vast areas in Western Tanganyika, is illustrated by the following:—

TABORA—I. RIDGETOP

	Coarse sand	Fine sand	Silt	Clay	
4096 0-6″	55·1	19·6	3·2	22·3	Sandy brownish grey topsoil.
4098 12-18	47·2	21·0	3·4	30·1	Changing almost imperceptibly to
4100 24-36	38·7	20·3	3·2	39·4	
4103 60-72	27·8	28·4	6·3	38·4	Reddish orange loam.
4106 96-108	34·3	24·5	8·4	32·7	Similar with some quartz gravel.

II. MIDSLOPE

	Coarse sand	Fine sand	Silt	Clay	
4122 0-6″	45·3	40·8	6·0	8·5	Dark grey fine sand.
4124 12-18	47·8	38·5	6·3	9·8	Slightly brownish grey fine sand.
4126 24-36	47·5	38·0	5·0	10·8	Changing to
4129 60-72	40·6	47·1	8·5	5·3	White, gritty cohesionless sand.
4132 96-108	45·0	43·6	7·1	5·6	Similar with altered granite.

III. BOTTOMLAND

	Coarse sand	Fine sand	Silt	Clay	
4171 0-6″	41·5	31·8	12·5	12·4	Bluish-grey sandy clay.
4173 12-18	40·1	22·3	14·7	22·1	Lighter coloured sandy clay.
4175 24-36	26·6	16·9	7·3	42·8	Very stiff greyish clay.
4177 48-60	26·9	14·9	9·8	45·4	Similar with CaCO3 fragments.
4180 84-96	52·4	13·8	4·9	26·8	Greyish clay with fresh granite fragments.

The mid-slope soil is peculiar in that it is derived from altered granite which underlay an old swampy peneplain. The ridge tops carry mature soils on granite remnants above peneplain level. Drainage has now cut through the altered granite in places and the bottomland soil is developing on fresh granite. Some overwash on to the bottomland from the higher soils is evident. The lower layers of Profiles I and III show small differences in mechanical composition which are quite insufficient to account for the large difference in clayeyness.

The following profiles may be of general interest:—

RUKWA

	Coarse sand	Fine sand	Silt	Clay	
3321 0-6″	1·0	6·7	23·7	55·4	Dark slate coloured hard clay.
3322 6-12	0·3	5·1	25·6	60·2	Similar with marked columnar structure.
3323 At 18	1·2	4·5	24·8	62·1	Cloddy, a little CaCO3
3324 At 30	1·2	4·0	19·3	67·5	Similar, speckled with CaCO3
3325 At 36	1·9	4·3	32·9	41·5	
3326 At 48	2·3	7·6	29·6	33·2	Brittle lacustrine material with CaCO3 and soluble salts.

This is a solodised soil derived from saline lake-bed material which is partly diatomaceous earth and partly altered clay suggestive of a meta-bentonite. Both silt and clay contents are high. A limited washing down of clay is apparent.

KIGURA

	Coarse sand	Fine sand	Silt	Clay	CaCO3	
4724 0-6″	12·4	13·9	6·8	6·9	47·5	Pale brownish grey coarse sand.
4725 6-12	17·5	11·4	6·7	3·6	48·1	
4726 12-18	17·6	13·2	4·2	4·4	47·3	

This is an immature, highly calcareous soil on recent volcanic ash. Silt content relative to clay is high.

NZEGA

	Coarse sand	Fine sand	Silt	Clay	CaCO3	
2637 0-6″	39·0	33·4	4·5	22·4	Nil	Grey difficultly friable top soil.
2638 6-12	26·4	23·2	4·1	44·8	Nil	Brownish-grey, stiff subsoil.
2639 12-18	22·7	18·8	5·0	47·5	0·17	Similar, more friable.
2640 18-24	48·0	13·3	6·3	22·2	0·13	Light grey.
2641 24-36	59·0	12·2	6·6	11·9	0·24	Similar.
2642 36-48	56·3	20·4	6·5	6·6	0·25	

The washing down of clay in this profile more or less coincides with the leaching down of $CaCO_3$. The latter is lithological rather than pedocalic, i.e. present conditions are through-leaching, calcium carbonate being a fugitive constituent.

The three following profiles illustrate mature red-earth types on secondary parent materials:—

KIDICHI (On Marine Sediments)

	Coarse sand	Fine sand	Silt	Clay	
1926 0-6″	51·3	25·9	1·6	20·2	Reddish chocolate fine sand.
1927 6-12	43·9	15·2	0·8	38·9	Uniform red-brown loamy soil, texture lightening somewhat with depth
1928 12-18	34·7	14·3	0·9	48·4	
1929 At 24	38·0	15·7	1·1	42·6	
1930 At 36	34·9	16·9	1·2	45·9	
1932 At 72	32·8	16·4	0·4	50·5	

KANSANSHI (On Shales)

	Coarse sand	Fine sand	Silt	Clay	
4236 0-6″	7·8	39·7	10·1	40·4	Brownish-red stiffish soil.
4237 6-12	7·7	37·5	8·7	45·3	Very little change with depth.
4238 12-24	7·1	36·1	9·0	47·5	
4239 24-36	5·7	35·9	10·3	48·1	
4240 36-48	5·8	36·5	13·7	44·6	
4241 48-60	5·4	37·4	14·2	44·3	

NYAKATO (On Sandstone)

	Coarse sand	Find sand	Silt	Clay	
2610 0-6″	45·9	16·0	2·3	30·7	Dark-brown sandy loam.
2611 At 12	46·2	16·4	2·9	31·7	Gradual transition to Yellowish-brown stiff clay.
2612 At 24	40·0	17·1	2·3	41·1	
2614 At 48	39·6	17·5	2·8	42·2	
2616 At 72	32·2	18·0	5·4	46·7	
2618 At 96	30·0	18·4	2·9	51·2	

Clay contents are similar, though there are some differences in actual clayeyness and contents of silt and sands.

Summary

The lack of any consistent relation between mechanical composition of East African soils and their field properties is discussed.

An attempt is made to trace the changes in mechanical composition occurring with progressive soil development on various parent materials.

Examples are given to show the range of mechanical types found in East Africa.

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HORMONE SPRAYS FOR FRUIT

The recent rapid development in the investigation of growth-promoting substances have been closely followed by widespread attempts to apply the so-called plant hormones in horticultural practice. The use of synthetic growth substances to facilitate the rooting of cuttings became a craze almost overnight, and there is no doubt that remarkable results were achieved in many cases. There are still, however, species which resist all attempts to make them produce roots readily enough to make this method of propagation practicable on a commercial scale.

Other uses for growth substances have now become the centre of interest, and these form the subject of a review in the *American Fruit Grower* of June, 1941. Perhaps the most successful application has been the use of naphthalene acetic acid and naphthalene acetamide to control the pre-harvest drop of apples. Spraying with dilute solutions of these substances, by delaying the formation of the abscission layer, enables fruits to be kept on the tree until a desirable degree of colour and maturity is reached. Fruit dropping from pears, plums, apricots, oranges and cherries has also been reduced, and, in the case of the latter, the sprayed fruits showed a lower acid and higher sugar content than the controls. Satisfactory results with some English varieties of apple have been obtained by similar methods at the East Malling and Long Ashton Research Stations. The method appears to be of particular value in combating the effects of strong winds. Also of interest is the checking of bud development by hormone sprays. By this means the risk of frost injury to fruit blossoms in spring may be reduced. Indole butyric acid, applied unilaterally to shoots of young apple trees, causes more rapid growth on the treated side. By this means the development of narrow-angled and therefore structurally weak crotches can be avoided.

Nature, 4-7-42, p. 19.

THE PREPARATION OF GLUE

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Contrary to popular belief, glue is not normally made from the horns and hoofs of cattle, but by far the greatest proportion of the world's output is manufactured from low-grade hides and skins and from tannery and abattoir trimmings. In East Africa large numbers of low-grade sun-dried hides are forthcoming every year and many have been so irreparably damaged during drying that they can be of little value for leather production. In fact, their conversion locally into glue would do a considerable service to the hide and skins industry. The inclusion of damaged skins in export consignments lowers the reputation of East African hides and skins on the world's markets, because the extent of the damage cannot be assessed until after the hides and skins have been soaked and limed.

In this article it is assumed that glue will not be made locally from bones but from low-grade hides and skins and the trimmings from abattoirs and tanneries. First, a brief summary is given of the theoretical considerations involved and the practical means of achieving them. Later, details of preparation are given for low-quality glue, normal commercial glue and high-quality glue.

Theoretical Considerations

The solid matter in skin is composed chiefly of proteins belonging to the following groups:—Albumins, globulins, melanins, mucins, keratins, elastins and collagens. Of these, only the collagens are of value for glue production. The objects of the glue manufacturer are to remove the first five groups of proteins, boil the collagen to convert it into glue and leave the elastins behind as part of an insoluble residue. Albumins are water-soluble, the next three groups dissolve in dilute alkali, whilst the keratins can be easily separated from collagens because below 35°C. they are hydrolysed by alkalies at a faster rate.

The practical methods involve soaking the hide, etc., in water to remove dirt and blood and, at the same time, to remove water-soluble protein matter and, in the case of dried skins, to swell back the protein fibres to their normal size. The soaked hide is then put into alkaline solution, which may be saturated lime-water or a solution of the more caustic alkalis. This treatment removes those proteins soluable in alkaline solutions and also hydrolyses the more recently formed cells of the epidermal layer so that the epidermis, including the hair, can be rubbed or scraped off. After removing the hair, the skins are thoroughly washed with cold water to remove excess of alkali and are then heated with water to convert collagen into glue. The glue liquors are strained from insoluble matter, concentrated and allowed to cool so that they set to a jelly. The glue gel is cut into slabs and dried on frames until quite dry and ready for marketing.

Low-quality Glue

Low-grade glue is produced when inadequate precautions are taken to remove unwanted components. It is uneconomical to use hides and skins, and so low-grade glue should be prepared only from hide trimmings from abattoirs and hide-drying *bandas* or from trimmings and fleshings from tanneries. This raw material is in the form of small pieces, and the usual practice is to put them into cages and wash thoroughly in water to remove dirt, manure, blood and/or lime. The pieces can of course be washed in pits, tubs or tanks if no cage is available. Usually no alkaline treatment is given, but the washed trimmings go straight to the boiler and are heated with water. Boilers for glue should be double jacketed, and steam is the most convenient source of heat. The trimmings are slowly brought to the boil and are heated for a day, when the liquor is removed and strained and the residue given a second day's boiling with water. These liquors are usually sufficiently concentrated to yield a stiff jelly on cooling to room temperatures but, if too much water has been used, they must be concentrated by further heating. The liquors are strained by passing them first through a fine gauze filter and then through two or three layers of cloth. After straining, the glue liquors are poured into shallow trays and allowed to set. The gels are cut into slabs which are placed on wooden or wire frames to dry out completely. This usually takes seven to ten days.

A certain amount of finely divided insoluble matter will pass through the strainers and the resulting glue will be cloudy and dark. Also, a little hair may be incorporated in the final product and this still further reduces its general appearance.

Normal Commercial Glue

The same raw materials are used as in the making of low-grade glue, but the pieces of hide, etc., are treated with alkaline reagents after the preliminary washing. Also, low-grade sun-dried hides and skins can be used, but in their case soaking for from two to four days in water (preferably containing a disinfectant) is necessary to soak back the skin proteins to a condition resembling that in fresh hides.

If lime be the alkali employed, the trimmings and soaked hides are put into water saturated with, and containing an excess of, slaked lime of good quality. Liming is usually done in pits and the mixture is agitated twice daily with either poles or paddles. After about twelve days' liming, the hides and trimmings are removed, washed, and scraped to remove the hair. A revolving drum can be used for trimmings, but whole hides or skins are best dehaired by hand. The revolving drum or cage is fitted inside with stops or vanes which lift up the hide trimmings and later drop them; this continual rubbing removes the hair. If this revolving cage or drum dips into water, free lime can be washed out whilst the skins are being dehaired. Skins dehaired by hand must be well washed subsequently in water for at least two hours to remove as much lime as possible. Better results are obtained if the skins are cut into small pieces before washing.

Because liming takes such a long time, skins are commonly soaked in a 1—4 per cent caustic soda solution, with which they are ready for dehairing in a few hours. As in the case of liming, the excess of free alkali must be removed after dehairing, and whole skins should be cut up before washing.

The dehaired and washed skin is then pressed to remove surplus water and put into a double-jacketed boiler with water. The weight of water used should equal the original dry weight of dried hides or half the original weight of fresh hide or trimmings.

The first boiling lasts for seven hours at 70° to 90°C. The liquor is strained off and a second boiling at 100°C. made with a similar quantity of water. The second liquor is likewise strained off and two or more subsequent boilings made until the amount of glue being extracted is very small. Each successive glue liquor becomes darker in colour and contains more of the finely divided protein matter. Usually the liquors from the series of boilings are mixed together, but occasionally they are kept separate and different qualities of glue put on the market.

Sometimes the glue liquors are clarified before they are allowed to set. This is done to remove colouring matter and the finely-suspended proteins and so enhance the value of the product. I have found that, in East Africa, clarification is best done by adding 5—10 per cent of defibrinated or citrated blood to the glue liquors at about 40°C. The mixture is then heated until the blood coagulates and collects in fairly large protein aggregates (80°—90°C.). The liquor is then removed from the source of heat and allowed to stand, when much of the coagulum (containing colouring matter and proteins) collects as a scum and can be ladled off. The still hot liquid is then strained through cloth into shallow pans and is allowed to cool and set. The firm jelly is then cut into rectangular slabs and placed on drying frames.

Drying is probably the most troublesome part of the preparation and a warm airy building is very suitable. If put out in the sun to dry the outer layers dry rapidly and become distorted so that the inner moister layers dry out slowly. Also there is a grave risk of the gel melting and the glue being lost. On the other hand, if the air is very humid, drying takes place very slowly and moulds may develop on the glue or the glue may take up moisture and become liquid again. Warm dry air is the ideal for drying and, provided care is taken, little difficulty will be experienced in the dry season.

Modern glue makers often concentrate their glue liquids to a highly concentrated liquor before cooling and drying, but this should be done under a vacuum and so is not normally possible in East Africa. A high degree of concentration at ordinary pressures is liable to reduce considerably the quality of the glue.

High-quality Glue

This is made from the same raw materials as the normal commercial grade, but the preparation is more elaborate. After being dehaired, cut into small pieces and thoroughly washed, the hide is treated with dilute acid to remove as much alkali as possible. Any acid can be used, but weak organic acids or hydrochloric acid are probably the best. The hide is treated with acid until a piece on sectioning gives no trace of pink colour in the interior when treated with a drop of phenol phthalein. After the acid treatment, which results in a

clearer glue, the hides are washed thoroughly in water and pressed to remove surplus moisture.

Boiling is done as for normal commercial glue, but in the first boiling the temperature is not allowed to rise above 80°C. Four to five hours' boiling is allowed, after which the liquor is strained off. This liquor is strained and clarified separately and yields the highest-quality glue. A second boiling for five hours at not more than 90°C. is then made, and this liquor is again treated separately to yield a slightly lower-quality glue. The third and fourth boilings at 100°C. are then made and these liquors are mixed together and clarified to give a slightly lower grade of glue. The fifth, sixth and seventh boilings are carried through and the three liquors are mixed together and can be clarified to yield normal commercial glue.

Costing

It is unfortunate that I can give no costing details as the tests made have all been on a small scale. The yield of glue from fourth-grade sun-dried hides will probably be in the region of 30 per cent; in trials at Mpwapwa, using never more than three hides at a time, the yield of glue has varied from 21 per cent to 43 per cent of the dried hide weight.

Recently, also, the Hides Exporters Group has dropped the price of fourth-grade hides to a very low level. These hides are useless for leather production and take up valuable cargo space, so that efforts are being made to remove them from export batches and to discourage their appearance in the normal hides and skins trade. At their present low price, fourth-grade hides could be economically converted into glue and a drug on the market thereby turned to good account.

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HYBRID MAIZE IN KENYA

In the *Journal*, Vol. 3, p. 191 (November, 1937), attention was drawn to the possibility of improving maize yields in Kenya by producing inbred strains and subsequently crossing them. Hybrids so produced have proved in both the U.S.A. and South Africa to yield decidedly better than strains developed by other means. In Kenya, however, it is disappointing to record that the maize hybrids developed after a number of years' work have failed to yield significantly better than the controls and have accordingly been discarded.

It must be remembered that Kenya maize is already very crossbred compared with that used in the U.S.A. and South Africa, so that the chances of heterosis, beyond that obtained in the ordinary cross-bred maize, from crossing inbred lines is reduced. Furthermore, the original lines chosen were largely restricted to the few showing some resistance to disease and it is likely that this material did not contain a sufficient number of genetically different lines.

In future selection will be relied upon as the means of improving Kenya maize until such time as there is a sufficiency and continuity of staff to organize the work as effectively as the wheat work.

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COOKING OF SOYA BEANS

Without any preliminary treatment the raw beans are roasted as coffee beans are roasted, but without the addition of fat or water. The process takes a few minutes. Roasting can be done on or in an oven or open fire. Do not over-roast, as then the product is bitter. Roasting is complete when the beans take on a brown colour. Following the roasting process the beans are boiled for upwards of two hours, then well mashed. If the roasting is properly done, the final product has a very pleasant nutty flavour, with the usual bitter taste eliminated.

For native use, the mashed final product can be mixed with *posho* or *ugali*, consisting of maize, *mtama* or *wimbi*. For Europeans, the mashed product can be used as it is, together with other vegetables or meat; or it can be used as a basis for vegetable "cakes", to take the place of the commonly used lentil.

We have found that preliminary soaking of the beans in water, followed by roasting, destroys the flavour. Just soaking and boiling results in a very flavourless, rather bitter product.

We have only experimented with a large yellow type, the origin of which is unknown at present. It is a variety that has done exceptionally well in Nyanza Province.

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THE PART PLAYED BY LEGUMES IN THE DIET OF THE NYASALAND AFRICAN

WITH NOTES ON THE COOKING AND PALATABILITY OF A NUMBER OF DIFFERENT KINDS

By Jessie Barker, M.A. (Cantab.), Dip.Diet. (Lond.), Nutritional Investigator, Nyasaland

Cooking Trials

Trials were carried out during 1941 at Mwera Hill on the seeds of a number of leguminous plants, in order to compare their cooking properties and palatability. Many of the kinds were in common use in the country, while a few were recent introductions. All the available varieties of each species were tested, viz.:—

The cooking times given in Table I are, of course, only approximate and give the range found within the species in question, e.g. with soyas, one variety only took three hours, while another needed 5½ hours. The standard adopted for "cooked" was that of the Nyasaland African, i.e. when the bean is very soft and easily broken between the fingers; by European standards it would then be considered slightly overcooked.

Scientific and Common Names	Native Names (1)	Amani Numbers A.	Mwera Hill Numbers M.
Arachis hypogaea (Groundnut, Peanut) ..	Ntedza (N) Ntesa (Y) Nsawa (C)	—	89, Local.
Cajanus cajan (Pigeon pea, "Dhal")	Nandolo (N) Mbelemende (Y)	1264	23, Local.
Canavalia ensiformis (Sword bean, Gotani bean)	—	—	12
Cicer arietum (Chick pea)	—	—	34
Dolichos lablab (Hyacinth bean)	Nkhungudzu (N) Ngwingwisu (Y)	Samples not available at time of trials.	
Glycine hispida (Soy or Soya bean) ..	—	—	31 Hermann, 38 Easy cook, 73a, b, and c, Hernon 6, 25 and 268.
Mucuna aterrima (Velvet bean, Bengal bean)	Kalongonda (N) Tangale (Y)	Samples not available at time of trials.	
Phaseolus acutifolius (Tepary bean)	—	815/39	33
Phaseolus aureus (Gram)	Mphodza (N) Mbweso (Y)	806/39 or 1265	30
Phaseolus lunatus (Lima bean, Butter bean, Madagascar bean)	Ntambahodo (N) Kamupanda (N) Mayemba (C)	809/39, 811–814/39, 1265–66, 1281	
Phaseolus vulgaris (Haricot bean, Kidney bean, French bean)	Mbwanda (N) Chimbamba (N) Kayera (C)	1268–70, 1272–76, 590, 594–95/39, 623–24/39	
Pisum sativum (Field pea, Garden pea) ..	Sawawa (N) Kabaifa (N) Ndozi (C)	282/38, 638/38 —	26, Local. 29, Pride of the market. 28, Daisy.
Vigna unguiculata (Cowpea, Kaffir bean) ..	Nseula (N) Khobwe (N) Ngunde (N)	1278 —	74 ex S. Rhodesia. 75 ex S. Rhodesia.
Voandzeia subterranea (Bambarra groundnut, Ground bean)	Nzama (N) Njama (Y) Kanabulunji (C)	1271	

FOOTNOTE (1) (N)=Chinyanja. (Y)=Chiyao. (C)=Chichewa.

TABLE 1.—COOKING AND PREPARATION

Scientific and Common Name	Length of Cooking Required				Skin of Dry Bean	
	Dry unsoaked		Dry soaked	Fresh	Texture, flavour	Methods of removal
	Hrs.	*No. (a)*	*Hrs.(b)*	*Hrs.*		
Arachis hypogaea (Groundnut, Peanut)	3–4	4	—	—	Very thin, slightly bitter.	Very easily by hand if necessary.
Cajanus cajan (Pigeon pea, *Dhal*)	4–5	5	2–3	1½–2	Tough, slightly acrid	1. Parboiling followed by pounding with ashes. 2. Soaking in boiling water, skinned by hand. 3. Grinding and winnowing.
Canavalia ensiformis (Sword bean, Gotani bean)	5–6	—	3–4	2–3	Outer very tough, inner soft.	Easily by soaking.
Cicer arietum (Chick pea) ..	5–6	—	2–3	—	Very tough.	Easily by soaking.
Dolichos lablab (Hyacinth bean)	5–6	—	—	1	Very tough, bitter.	Roasted to crack skins, ground, pounded skins winnowed off.
Glycine hispida (Soy or soya bean)	3–5½	4–7	2–4	1	Thin, tasteless.	Very easily by soaking
Mucuna atterrima (Velvet bean, Bengal bean)	—	(c) 6–7	—	—	Very tough, very bitter.	Difficult to remove but becomes loosened by the long cooking which bean needs.
Phaseolus acutifolius (Tepary bean)	1½–2	2½	—	—	Thin, tasteless.	Easily by soaking.
Phaseolus aureus (Green gram)..	1½–2	2½	¾–1	—	Fairly tough.	Usually by grinding and winnowing, easily detached by soaking.
Phaseolus lunatus (Lima or butter bean, Madagascar bean) ..	2–2½	2–3	1½–2	—	Of most kinds fairly tough, many bitter.	Easily by soaking.
Phaseolus vulgaris (Haricot bean, Kidney bean)	1½–2½	2–3	¾–1½	1	Soft, tasteless.	Easily by soaking.
Pisum sativum (Field pea, Garden pea)	2–3	3–4	1½–2½	¾–1	Soft, tasteless.	Easily by soaking.
Vigna unguiculata (Cowpea, Kaffir bean)	2½–3	4	2–2½	1	Tough, very slightly acrid.	When fresh by soaking, when dry by pounding.
Voandzeia subterranea (Bambarra groundnut)	2½–3	2–3	1½	½–¾	Fairly tough.	Easily by soaking.

(*a*) Number of times that water is added in native method of cooking.
(*b*) Beans soaked overnight (approx. 15 hours) in cold water.
(*c*) The cooking water is thrown away each time and the beans well washed, otherwise they are very bitter.

The Typical Meal

The bulk of the Africans in Nyasaland are maize-eaters who take their meals either once or twice a day. The meal consists of a large bowl or basket of *nsima* (porridge) together with a small amount of a well flavoured and salted cooked dish, the *ndiwo*.[1] Often a group of men and women eat together and hence they have a choice of different *ndiwo* with which to eat this *nsima*.

By far the most commonly eaten *ndiwo* is one prepared from leaves. Whenever possible groundnuts are added to this dish as its palatability depends very largely on their presence. Hence groundnuts are of great importance from the native point of view. As they are also of high food value, they deserve first place in our consideration.

The use made of Groundnuts in the Cooking of Leaves

A great variety of leaves, both cultivated and wild, are in common use. The methods of preparation and cooking vary slightly from

[1] The native terms *ndiwo* and *nsima* will be used throughout this article as there seem no appropriate English equivalents.

leaf to leaf, but the general method is the same for all. The leaves are boiled with or without the addition of native potashes. Salt is added sometimes at the beginning of cooking, but usually when the leaves are nearly done. If tomatoes are available, one or two will be added about 15 minutes before the leaves are cooked. When the leaves are well softened and there is little surplus water left, a handful or two of finely pounded groundnuts are placed on the top while the pot is still on the fire. After about five minutes, the mixture is given a very thorough stir and the pot placed at the side of the fire while the cooking of the *nsima* (porridge) proceeds.

The Effect of the Addition of Groundnuts

Groundnuts are very rich in fat. When they are pounded and mixed in with cooked leaves they form with the liquor a very appetising sweet tasting sauce. It is this sauce which "makes" the dish in the eyes of the African. Into it he can dip a seemingly never-ending succession of small lumps of *nsima,* which he proceeds to swallow until he reaches the blessed state of repletion, the goal of every meal. If groundnuts have not been added the lumps of *nsima* are duly dipped, but the "sauce" neither tastes well nor sticks satisfactorily to the lumps. Hence the meal is soon at an end, a large amount of *nsima* is left over and hunger is only temporarily appeased.

Pounded groundnuts are also added in the cooking of the large number of edible fungi which are eaten in the rainy season. In certain parts of the country they are used in the cooking of a number of other vegetables, such as brinjals (egg plant), a nearly related wild fruit, *zimpwa* (N), young pawpaws and loofahs.

If it is desired to introduce vegetables new to the African, such as carrots, swedes or possibly Chinese gooseberries,[1] an acceptable way is to add pounded groundnuts, as described above, after thorough cooking and mashing of the vegetable.

Other Ways of Eating Groundnuts

It is hardly necessary to remark upon the popularity of the groundnut when raw. Anyone who has watched women and children harvesting the crop or seen the women and girls shell the daily quota to add to the *ndiwo* will testify to this. Likewise, the fact that it is well-nigh impossible to prevent petty thieving from an accessible store is further evidence of their popularity with all.

The nuts are also very well liked when added in the pounded form either to boiled rice or to mashed sweet potatoes. Among the Akonde they are often added to boiled bananas. They are seldom eaten cooked alone as *ndiwo*.

Groundnut Oil

In the few places in the country where nuts are plentiful, e.g. parts of the Fort Johnston and North Nyasa districts, a certain amount of oil is extracted. This finds a ready sale either to Europeans, Indians or to the wage-earning African, as it makes a very popular addition to almost any kind of *ndiwo*.

The Cooking of Beans and Peas

The important use of beans or peas is to serve as *ndiwo*. All kinds are preferred eaten fresh, in which case they are usually served boiled whole in their skins. When dry they may either be cooked thus whole in their skins, *wa mphumphu,* or they may be boiled after removal of the skins and mashed to form a very smooth mixture known as *chipere*. The method adopted depends largely upon the kind of bean to be cooked. It will be seen from Table I that a number have either tough and/or bitter skins, hence it is these kinds which are frequently served as *chipere,* e.g. pigeon peas, gram, some lima beans.

The African women do not judge the degree of cooking needed for any particular kind of bean by the length of time on the fire, but by a far sounder criterion, i.e. by the number of times that the pot has to be refilled with water before the beans are sufficiently soft. Some beans only require one such addition of water, while others, such as velvet beans, need as many as six or seven. In this instance the long cooking is to remove the bitter flavour of the bean.

Beans may also serve as a "snack", in which case they are usually boiled in their pods when still fairly young. When the beans are soft a handful of pods are taken by each participant and the contents eaten one by one. Certain kinds, such as the Bambarra groundnut and cowpea, are very commonly eaten in this form, which is known as *mikowe*.

Among the Akonde and Asukwa in the north of the country, beans are often eaten boiled together with whole maize. The mixture is known as *ngata* and frequently forms the main meal of the day. Among the Achewa the same mixture, *vingowe,* is eaten. Cowpeas are commonly used for this purpose and the dish is often eaten in the hoeing season as it is said to produce great strength for the work in hand.

[1] A large less sweet type of the Cape gooseberry.

TABLE 2—EDIBILITY AND PALATABILITY

Name	Palatability of the Cooked Seed		Edibility of Leaf	Edibility of Pod	Popularity of the Plant in Nyasaland
	Flavour	Texture			
Groundnut ..	Sweet.	Nutty.	Young leaves eaten occasionally.	Not eaten.	Extremely popular, particularly in the pounded form as an addition to cooked leaves and certain other vegetables.
Pigeon pea ..	Slightly acrid if cooked with skins.	Soft, smooth if skins are removed.	Not eaten.	Eaten when very young.	Well liked by certain tribes, e.g. the Achewa and Anguru in the south and the Akonde, Atumbuka and Atonga in the north of the country.
Sword bean ..	Tasteless due to long boiling.	Mealy.	Not eaten.	Eaten when young.	Known at present to only few in the country.
Chick pea ..	Innocuous.	Soft, smooth if skins removed.	Not eaten.	Not eaten.	Unknown in the villages, not liked by the few upon which the peas were tried.
Hyacinth bean..	Slightly bitter unless skins are removed.	Soft, smooth if skins removed.	Young leaves eaten occasionally.	Young pods eaten.	Fairly commonly grown in the S. Province and in the far north of the country.
Soy or Soya bean	All white and yellow kinds sweet.	Firm, smooth.	Not eaten.	Not eaten.	Not liked in the plain boiled form, mainly because of the firm texture of the cooking bean.
Velvet bean ..	Innocuous after long boiling.	Soft, smooth if skins are removed.	Not eaten.	Not eaten.	Grown in small amounts in the S. Province, seldom seen in N. Province.
Tepary bean ..	Good.	Soft and smooth.	Not eaten.	Not eaten.	Not as yet at all widely grown, the beans appear to be well liked by the few who have tried them.
Gram	Good.	Soft, smooth with skins removed.	Not eaten.	Not eaten.	Fairly widely grown and well liked in the S. Province and in the north of the country.
Lima bean ..	Variable, many bitter due to skins	Soft, smooth with skins removed.	Young leaves eaten occasionally.	Eaten.	Commonly grown over fences in the S. Province for its pods, beans and leaves commonly grown in the north of the N. Province and less commonly in the central section, for its beans and leaves.
Haricot bean ..	Good, several kinds sweet	Soft and smooth.	Eaten, well liked.	Eaten.	Beans and leaves very popular all over the country, pods well liked in S. Province and leaves commonly dried in N. Province.
Field pea ..	Good, sweet.	Soft and smooth.	Eaten, much liked.	Not eaten in this country.	Peas and leaves very well liked wherever climatic conditions allow of its growth.
Cowpea ..	Good, very slightly acrid.	Soft, floury, smooth if skins removed.	Eaten, well liked.	Eaten.	Peas and leaves well liked in all parts of the country, pods well liked in S. Province. Leaves are very commonly dried in the N. Province.
Bambarra groundnut ..	Good, sweet.	Soft, smooth if skins removed.	Not eaten.	Not eaten.	Grown in small amounts all over the country, well liked.

Native Preferences

(See Table 2)

Naturally the most popular kinds are those which have thin tasteless skins and which cook quickly. The many kinds of haricots fulfil these conditions and are universally well liked. There are a very large number of varieties of this bean, differing from each other slightly in flavour and in texture of the skin. Probably the most popular kind in Nyasaland is the Canadian Wonder, *chimbamba,* while a small white kidney bean is also much liked.

Of the four important kinds of beans and peas grown in this country the following is their probable order of popularity:—(1) haricots, (2) field peas, (3) cowpeas, and (4) after a fairly long gap, pigeon peas. Both gram and certain limas are well liked, but are only grown in small amounts.

The Soya Bean

The soya bean contains a considerably higher proportion of protein than the other leguminous seeds and is also rich in fat; hence it is a very valuable food for native diets.

Unfortunately it differs from the other beans and peas in that its flesh does not become friable and easily broken on cooking. The eater finds that when he picks up a few of the beans with his lumps of *nsima* they feel firm to the touch and do not crumble and mingle with it like other beans. Hence, quite naturally, he assumes that the beans are not properly cooked and may refuse to eat them. Another point in their disfavour is that they require soaking overnight, a process new to the average Nyasaland woman.

Hence when soya beans are to be introduced, either in rations for labour or into the diet of an institution such as hospital, school or prison, there is a need to go very carefully and slowly at first, lest such a good food be damned for ever in the eyes of that particular group of Africans.

Experience has shown that it is unwise to issue the beans raw, even after careful instruction in cooking has been given, until they have become well known and accepted in the cooked form. If they are issued boiled they must be well cooked and given in small amounts at the start (see *Rhodesia Agricultural Journal,* Vol. 38, No. 9).

A scheme which has proved successful in Southern Rhodesia has been to mix a small amount (5 per cent) with other beans, e.g. haricots or cowpeas, and then to increase the proportion gradually up to possibly a half and half mixture. If there is difficulty in the acceptance of the whole beans, then they should be made into a meal and a proportion of this mixed with the staple flour in use. The meal will not keep for more than about 36 hours unless the beans have previously been roasted for some 10 to 15 minutes. The meal from roasted beans is very palatable and keeps well. It can be used in amounts up to 20 per cent of the mixture with all kinds of flour. It is of particular value with cassava flour, which by itself is of such poor nutritive value.

The Leaves of the Legumes

The important part played by leaves in the diet has already been mentioned. Of the commonly cultivated leaves, three important ones are those of leguminous plants, namely cowpea, haricot bean and field pea. A large number of wild leguminous leaves are also in common use.

Leaves are very valuable foods from the nutritional point of view because they contain, in addition to large amounts of some of the important vitamins and minerals, appreciable quantities of good-quality protein. Hence, when judging the merits of any particular legume for village use, its leaves must receive as much attention as its seeds, if not more, and, whenever possible, preference should be given to those kinds which give good yields of palatable leaves.

Comparative Yields of Leaves

Haricots and field peas both give good yields of palatable leaves, but unfortunately have only a limited distribution in this country because of climatic conditions. Doubtless, when there is more general knowledge of methods of irrigation, they will be more widespread. Field peas are particularly valuable as they flourish in the cold dry season when other leaves are scarce. With successive plantings a supply of leaves can be obtained throughout the dry weather.

The cowpea, however, seems to flourish almost everywhere and is a crop to be encouraged. It gives a very good yield of edible leaves. These make a very good dried product, *mfutso,* and in the Northern Province large quantities are dried every year for use in the dry months when fresh leaves are scarce.

The Pods of the Legumes
(See Table 2)

Among the tribes in the Southern Province considerable use is made of the green pods of cowpeas and lima beans and to a lesser extent of haricots.

The pods are usually cooked mixed with some fresh beans or peas and frequently leaves are added as well. In the Northern Province pods are seldom eaten.

The Frequency of Use of Groundnuts and Beans or Peas

The foods used for the preparation of *ndiwo* can be divided into (1) leaves, (2) beans or peas (3) miscellaneous, the important items in the last group being fish, meat, insects and fungi.

The following is an estimate, thought to be fairly accurate for the country as a whole,[1] of the frequency of use of the foods in these three groups:—

Leaves eaten 4–5 days a week, i.e. about 230 days in the year.

Beans eaten 1–2 days a week, i.e. about 75 days in the year.

Miscellaneous foods 1–2 days a week, i.e. about 60 days in the year.

From these figures we can arrive at a rough estimation of the amounts of groundnuts and beans needed in each household or "hut" and hence in each village.

During the months when food is plentiful, two meals are normally eaten daily; when it is scarce or when there is heavy work in the gardens there will be only one meal, usually at sundown. For purposes of this rough calculation we will assume that two meals are eaten for six months and one meal for the other half of the year. Thus leaves, and hence groundnuts, will be needed for some 345 and beans for about 112 meals during the year.

Provided that groundnuts are plentiful, they are added in amounts of about 1 oz. to every 3 oz. of leaf to give a fairly liberal adult helping, i.e. 345 oz. or 22 lb. will be needed per adult every year.

If we assume a little over three individuals as the average number per hut for a typical Nyasaland village, or in terms of adult requirements about $2\frac{1}{2}$ individuals, we arrive at the yearly needs per hut as 22 x $2\frac{1}{2}$ lb. or 55 lb. and for a village of 30 huts, some 1,650 lb. of shelled nuts. This amount makes no allowance for nuts eaten as "snacks".

With beans or peas, $2\frac{1}{2}$ oz. gives a fairly liberal helping, therefore the annual requirement is $2\frac{1}{2}$ x 112 oz., about $17\frac{1}{2}$ lb. per adult, the annual requirement per hut about 44 lb. and for a village of 30 huts about 1,320 lb. of shelled dried beans or peas.

The Place of Beans and Groundnuts in Institution Diets

It will have been noticed that beans are not eaten in the villages very often, nor in very large amounts; they are well liked but they are not welcomed more than once or twice a week. The usual reason given for this moderation is because they are apt to produce digestive disturbances. In the diets of institutions, however, such as hospitals, schools or prisons, beans often play a very prominent part. The reasons are fairly obvious; beans are usually easy to get, easy to store, and are cheap. Groundnuts, on the other hand, are seldom used, partly through ignorance of their value when added to leaves and partly because they are both dearer and more difficult to obtain. It is to be hoped that in the future beans will be relegated to a less important role and that efforts will be made to provide, with the help of groundnuts, at least as much variety in *ndiwo* in institutions as the African is accustomed to in his own village.

Comparative Value of the Plants

(*a*) *Plants in common use.*—The importance of the groundnut has previously been stressed. Not only is it of high nutritive value but its use in the pounded form renders a large range of leaves and other vegetables palatable.

Taking the country as a whole, cowpeas come next in importance. The plant is very hardy, produces a good yield of peas and a very good yield of leaves, both of which are well liked. The dried leaves play a valuable part in providing *ndiwo* in the long dry season which prevails in much of the Northern Province.

Haricots and field peas are universally popular and produce good yields of seeds and of palatable leaves. Unfortunately the distribution of both is limited by climatic conditions and haricots are often an unreliable crop.

The pigeon pea has the disadvantages that its leaves are inedible, its pods subjected to various insect pests and the peas have a slightly acrid flavour distasteful to some. On the other hand, it is extremely hardy, bears over several months of the year for several years in succession if desired, while at the same time its

[1] Except for the lake-shore areas, where fish is available in large amounts, and parts of the hill areas of North Nyasa and Mzimba districts where beans are extremely plentiful.

deeply penetrating nodule-bearing roots are doing good work improving the soil. It forms a valuable standby crop in many parts of the country.

Lima beans are hardy and bear good crops of either green pods or beans. Where water is available in the dry season they will bear for several years in succession. The leaves also are edible but are not very popular. The beans of many of the kinds are bitter and it is possibly lack of the seed of the good kinds, such as the butter beans that prevents such a useful crop from being more widely grown.

Neither the leaves nor the pods of the various grams are edible. The plants, however, are useful as they thrive in parts too hot or dry for haricots and the seed is well liked.

Hyacinth and velvet beans are of no particular merit. Both beans take a long time to cook, the leaves of the former are occasionally eaten, but those of the latter are inedible. Both plants, however, are hardy and are useful in years of shortage of food.

(*b*) *Plants not at present in common use.*—Of these, soya beans are the most important. The beans are very valuable for their high content of fat and protein and good yields are obtained in Nyasaland. There are two serious drawbacks likely to prevent their ready adoption as a village crop, first, the dissimilarity of texture and flavour from that of other beans and, second, the fact that the leaves are inedible. Hence as much effort as possible should be made to introduce them *in a palatable form* into the diets of all types of institutions such as schools or hospitals and in the rations of labour, in the hope that the prejudice at present existing against them may be broken down.

The sword bean should prove useful in places such as the lake shore, where other beans do badly, particularly in institutions where large yields are needed. The plants are perennial, very hardy and both pods and beans are palatable when young.

The tepary bean seems but a poor substitute for the haricot; the bean itself differs only slightly except for its small size, but the leaves are smaller, tougher and more bitter. The plant, however, is hardier than the haricot.

The chick-pea seems to have nothing to recommend it for use in this country. The skins of the pea are very tough and the leaves, even if edible, are too small to be of much value.

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BREAKING THE DORMANCY OF POTATOES

[Owing to the present shortage of potato seed the breaking of the tubers' normal dormancy may be important to growers. The following method has just been discovered by Mr. Hutton, of the Division of Plant Industry, Council for Scientific and Industrial Research, Australia, and published in their *Journal* (vol. 15 (3), p. 243, 1992).—R.M.N.]

Half fill a container with water, and add gradually over a period of a quarter of an hour small pieces of commercial calcium carbide. The object of adding the carbide slowly is to keep the bubbles of acetylene gas passing through the water, so that it becomes saturated. Approximately 8 oz. of commercial calcium carbide, costing about 6d., will produce enough acetylene gas to saturate 11 gallons of water, which is sufficient to treat 1 cwt. of seed potatoes at a time, and the container would have to be approximately of 16 gallons capacity. The uncut potatoes are placed in the acetylene solution and left there four to five hours. The potatoes must be whole at treatment, because if cut just before or after treatment the cut pieces will all rot. If the tubers do not need cutting into seed pieces they can be planted immediately after treatment provided the soil is warm and moist. When planting conditions are unsuitable, or the tubers need cutting into seed pieces, keep the tubers moist between bags in a warm place for about a week, and then plant as seed tubers or cut into seed pieces, as the case may be. If the tubers are cut they should be kept in a warm moist place for 48 hours after cutting and before planting, in order to obtain best results. It is admitted that the supply of calcium carbide is not as plentiful as it was before the war, but the fact remains it is cheap and easy to use. Some precautions are necessary. Calcium carbide must be kept dry in a tightly closed container otherwise it deteriorates rapidly. The acetylene gas is inflammable and so naked lights should not be allowed near the place of treatment.

The solution can be used again provided that a small quantity of carbide is added just before re-use, but it will not keep more than a couple of days.

If it is necessary to treat the seed tubers for the control of rhizoctonia it is advisable to use the acid mercuric chloride before the acetylene treatment. The treatment has the added advantage of killing any living potato moth grubs which are present.

EXPERIENCE WITH GRASS STOP-WASH LINES IN UGANDA

By G. B. Masefield, M.A., A.I.C.T.A., Soil Conservation Officer, Buganda Province, Uganda

This article follows as a sequel to a previous article of mine on "Narrow-base Ridges for Erosion Control", published in the *East African Agricultural Journal,* Vol. VII, p. 167 (1942). In that article the cost of making bunds and elephant grass lines was compared, and it was shown that the latter, are very much cheaper and are now usually preferred in Uganda where a choice has to be made of one method or the other. It is not to be inferred, however, from the following notes on grass lines that these are advocated for universal use in Uganda. In Buganda Province, the ideal for annual crops is a system of strip cropping with alternate strips under an elephant grass fallow (A. J. Kerr, *Empire Journal of Experimental Agriculture,* Vol. 10 (39), p. 125, 1942), which in itself is usually adequate to control erosion. Elephant grass lines are, however, useful when two contiguous strips have to be cultivated, and also in the closely populated areas around the larger townships where it is impossible to put half the land down to rest. In the Eastern Province, which for the most part is not elephant grass country, strip cropping with grass fallows is also advocated, but where contiguous strips are cultivated, erosion control is by leaving a belt of natural short grass from one to three yards wide uncleared between strips. In all areas grass stop-wash lines have proved of use, with certain qualifications, in permanent crops such as coffee, and, under certain circumstances, in plantains; similarly in Kenya they have been used in perennial crops such as pyrethrum and lucerne.

Grass top-wash lines are coming into increasing use all over the world, and while they are still comparatively new and the subject of much discussion, it is not inappropriate to summarize the experience gained with them in one particular country.

Elephant Grass Lines

Stop-wash lines of elephant grass (*Pennisetum purpureum,* Napier grass) are probably in wider use all over the world than those of any other grass. Thus we read that in South Africa "the grass is often planted on contour banks or in strips across slopes for the control of soil erosion" (W. Schultz, *East African Agricultural Journal,* Vol. VII, p. 118, 1941). In Puerto Rico: "the edges of the terraces . . . . are held by grasses. . . . Numbers of grasses have been tested for this purpose. Elephant grass, *Pennisetum purpureum,* is recommended" (E. Harrison, *Tropical Agriculture,* March, 1942, p. 54). In Kenya, a considerable number of European farmers have tried lines of elephant grass, as well as Native Agricultural School (M. D. Graham, *East African Agricultural Journal,* Vol. VII, p. 104, 1941). In Uganda during 1941 8,341 African plots were planted with elephant grass lines in Mengo District alone; in Kigezi they have become widespread since 1938 and are now a popular idea with the people. It is therefore appropriate to devote the bulk of this article to a discussion of elephant grass lines, more especially as Uganda is one of the chief natural homes of this grass, which is therefore under its natural conditions.

Types of Elephant Grass

Elephant grass in Uganda is a very variable species. Selections made at Kawanda Experiment Station have produced widely differing types suitable for fodder and other special purposes. For stop-wash lines two main types seem to have been used. One is the ordinary Buganda type, freely tillering and with leaves all the way up the stem; this is the one commonly seen in Uganda and also in Kenya. The other may be described as a "scrag-necked" type, since the lower part of the stem tends to become naked while the top bears a plume of leaves; it also appears to tiller less freely than the first type. I have only seen the "scrag-necked" variety in the Eastern Province of Uganda and in Kenya; it appears to be definitely less suitable as a stop-wash, and should be discarded for the purpose. Plates 1 and 2 illustrate clearly the difference between the two types.

In order to reduce the deleterious shade and root effect on adjoining crops (which will be considered below) attempts are being made in the Nsangi Soil Conservation Area to select a dwarf or under-sized form of elephant grass suitable for use as a stop-wash. So far a slightly under-sized form has been isolated, but not sufficiently different from the normal to warrant putting it out as a separate type; selection is proceeding.

Those who plant stop-wash lines will find that there is great variation in elephant grass in such points as tillering capacity, quickness of growth, and drought resistance. They should select according to their needs, remembering

that a good tillering strain will make an excellent stop-wash, but may spread outwards too quickly; a drought-resistant strain with great power of obtaining water will tend to rob adjoining crops; a quick grower will stop erosion sooner, but will need slashing oftener, but again will provide a greater quantity of mulching material.

All classification of types of elephant grass is subject to the qualification that material taken from one district and planted in another with a different climate sometimes shows considerable difference in habit in the new conditions. No two types can therefore be indisputably stated to be either different or identical until they have been proved to be so for genetic reasons.

There is no need to plant grass stop-wash lines on an exactly measured contour, provided a pretty good eye-contour can be laid out. A trench about three inches deep should be dug, and two stems side by side laid all along it and covered with an inch or two of earth. The ends of the stems should overlap, and in dry weather three may be used together instead of two. Stems used for planting should be fresh with the waxy "bloom" still on, and not very old and dry ones. Figs. 3 and 4 show the method of planting. In wet weather the majority of nodes will sprout, and a thick line of elephant grass is quickly obtained; even in comparatively dry soil this method of planting is remarkably successful. An alternative method of planting, by cuttings stuck upright in the soil, does not give good results except in very wet weather; it is, however, a cheap method of filling gaps in the main lines afterwards, if wet weather is chosen for this operation.

In order to prevent unruly growth over the plots and to curb excessive growth, it is desirable to slash the elephant grass back to ground level, or a little above it, at regular intervals. Experience in Buganda suggests that a three-month interval is generally suitable, but a two-month may be desirable in wet weather, and is also to be preferred during the growing period of the cotton crop owing to the bad effect of over-shading on cotton. Observations are in hand to determine the effect of regular two-monthly and three-monthly slashings on the habit of the elephant grass over a prolonged period.

The trash which is obtained from these slashings may at first be disposed of by laying it along the line on the upper side, to increase the stop-wash effect and especially to cover any gaps which may occur in the original line and which might be sources of gullying. After a time, however, more trash will be obtained than can be used in this way, and it can then be utilized in a number of ways—for a stock-feed, for composting, for bedding down animals, for fuel, for building, or for mulching suitable crops. It is this provision of mulching material which has largely recommended elephant grass lines in Uganda, since both the plantain and coffee crops benefit greatly from a mulch; yet to carry elephant grass from any distance is an expensive operation, therefore lines of elephant grass either amongst these crops or in adjacent plots are of great value from this point of view.

Elephant grass lines naturally have a tendency to spread outwards and broaden themselves, and this eventually has to be checked by chopping back the stools or they will take up too much room. In Buganda this point seems to be reached after a period of about three years.

A warning should be given that elephant grass lines should not be planted across land which is not clean of *lumbugu* (*Digitaria scalarum*), otherwise they will harbour this obnoxious weed and endless weeding will be necessary. On clean land the lines do not act as a reservoir of weeds to any serious extent.

Nobody who has seen lines of elephant grass, once thickly grown, can doubt that they will hold up any normal flow of water or earth, and in fact single lines will stand up to very considerable pressures of water when planted across deep gullies. The lines must be near enough together to prevent serious erosion, yet not too near because of the increase in "edge effect". In Buganda a 20-yard interval has been found generally suitable; in the case of grass lines it is better to work by a spatial interval rather than a vertical drop, because on steep slopes the latter will give lines so near together that the "edge effect" is pronounced. Wider intervals than this will often be safe in flatter types of country, but this is a matter which depends upon rainfall and soil type as well as slope, and must be left to local experience.

The degree of natural terracing which takes place along elephant grass lines can be considerable. In Nsangi Soil Conservation Area measurements were made and it was found that, twelve months after planting elephant grass lines in ordinary cultivation along true contours at intervals of a 6 ft. vertical drop (about 18 yards apart), terraces had developed with a vertical drop of 18 inches in many places, and 20 inches at the maximum. On the average, however, terracing in Buganda is not so rapid as this.

It is obvious, both from general considerations and from actual observation, that elephant grass lines, both by shade effect and by root competition, will reduce the yield of crops immediately adjoining them. The effect varies considerably with different crops. Cotton (always a sensitive crop to edge effect) seems to be the worst sufferer, one row and sometimes two next to the elephant grass being often obviously stunted. At the other extreme, sweet potatoes and beans often grow well right up to the elephant grass; other crops seem to occupy an intermediate position. Even with the same crop, there are variations in this respect due to factors which we do not yet understand. Plates 3 and 4 are photographs taken on a Kenya farm in one pyrethrum field protected by elephant grass lines; in Plate 3 the pyrethrum is growing perfectly well right up to the elephant grass, in Plate 4 two or three rows appear to be suffering badly from edge effect.

There is some doubt as to how far this deleterious effect is due to shading, and how far to root competition. In the report already quoted on soil conservation in Puerto Rico, we are told that "Elephant grass, *Pennisetum purpureum,* is recommended, but for narrow terraces on steep land its growth, by creating too much shade, is an objection". from the Bugusege Coffee Experiment Station of the Uganda Department of Agriculture the officer in charge writes of the elephant grass washbreaks: "It does not appear from observation that there has been any root effect on the coffee" but "the section left to grow for a year produced such excessive shade that the coffee trees were almost killed out". On the other hand, elephant grass roots are known to extend a long way in the same layers of the soil in which crops root. Mr. A. S. Thomas, of the Uganda Department of Agriculture, has taken soil cores to determine the proportions of coffee and elephant grass roots in plots where coffee adjoined elephant grass, and permits me to quote the following table which shows some of his results:—

LENGTHS OF ROOTS OF ROBUSTA COFFEE AND ELEPHANT GRASS IN 480 C.C. OF SOIL

Distance from Coffee	Distance from Elephant Grass	Depth	Coffee Roots	Elephant Grass Roots
		cm.	*cm.*	*cm.*
9 ft.	12 ft.	0–8	108	30
		8–16	130	53
		16–24	92	43
		24–32	42	10
12 ft.	9 ft.	0–8	19	136
		8–16	23	71
		16–24	11	47
		24–32	5	8

From this table it appears that coffee roots must meet considerable competition from elephant grass roots when the coffee trees are at as great a distance as 21 feet from the elephant grass; how serious this competition may be is difficult in my opinion to say, since coffee must also meet competition from the roots of shade trees and other trees, such at Para rubber, which are often deliberately interplanted in coffee without ill-effects. In the opinion of Mr. A. S. Thomas, Economic Botanist, the factor depressing the growth of coffee is that of root competition, not shade; for he points out that both Arabica and Robusta coffee grow wild in dense forests where the shade is much heavier than that thrown by lines of elephant grass.

Another fact, which suggests that root competition is an important constituent of the "edge effect", is that in irrigated plots in Kenya lucerne will grow right up to elephant grass with no ill effect, this being a case in which, owing to the irrigation, competition for water is not likely to be a limiting factor for growth.

There has been a tendency in certain quarters (both in Kenya and Uganda) to condemn stop-wash lines of elephant grass on account of this "edge effect". Before accepting this pessimistic outlook, it should be remembered that the chief alternatives are (*a*) bunds, which are about six times as expensive to make (*b*) lines of natural vegetation, which in many parts of Uganda would again consist of elephant grass. Again, to condemn elephant grass lines is *a fortiori* to condemn elephant grass fallow-strips, which in Buganda have been found to be the most satisfactory method of preventing both soil erosion and soil exhaustion. (A system of elephant grass lines at 20-yard intervals can, of course, easily be converted into one of alternate elephant-grass strips 20 yards wide by treating any two of the elephant grass lines as the outer lines of a strip, and planting up the whole area between with lines of elephant grass at three-feet intervals. It is hoped that the Muganda cultivator will in many cases take this step for himself.)

On the credit side for elephant grass lines should be set their manurial value as mulch-producers, which go far to outweigh any reduction in yield by "edge effect". There is also the fact that after a year or two a thick deposit of rich soil is formed on the upper side of the line, which will offset some tendency to reduced yield by crop plants just above the line. Finally, natural terracing will eventually produce a terrace wall, possibly some feet high, along the lines; and the roots of the elephant

grass, penetrating increasingly into this wall, will compete less and less in the surface soil amongst the crops immediately above and below them.

On the whole therefore it is likely that the good done by stop-wash lines of elephant grass far outweighs the harm. Although crop plants immediately adjacent to the lines may suffer in yield, and tend to catch the eye, on any severe slope the total yield on land protected by such lines will probably be much greater than that on unprotected land, though only very elaborate and prolonged experiments would detect the numerical difference. For coffee, however, it is wise to say that the lines should not be near together (20 yards is again probably a safe interval), and that the elephant grass should always be planted in the centre of an interval between two lines of coffee (African growers by no means always plant their coffee in lines), as elephant grass within two or three feet of coffee trees will certainly be harmful to them. The same applies to elephant grass lines in plantain gardens, but here some further explanation is necessary. The old custom of the Baganda was to plant these gardens on fertile soil, at fairly regular spacings, and to keep the surface of the soil permanently mulched; in such gardens neither soil erosion nor soil exhaustion occur, and it would be something of a sacrilege to plant elephant grass through a really well-tended "lusuku". Nowadays, however, the plantain gardens in the densely populated areas round the townships are nearly all scarred by actual or incipient gully erosion: on the worn-out soils the stunted plantains do not produce enough trash for a mulch; and the gardens are so much interplanted with other crop plants—cassava, coffee, mango trees, Cape lilac, and many others—that in many cases the interspersed plantings could not possibly provide a mulch for the whole surface. In such gardens the only practicable way of reducing erosion is by planting grass wash-stops, for which at present elephant grass is usually the only material available; though with or without these wash-stops the yield from such areas will remain very low.

One other type of "edge effect" may be mentioned before leaving the subject, and that is the depredations on crops of vermin—ranging from rats to ground squirrels—which may find cover in the grass lines. This is not an important factor in Buganda with elephant grass lines, though it becomes more serious with wide strips of elephant grass.

Other Grass Lines

Lemon Grass (*Cymbopogon citratus*).—This grass has been widely used as a small-scale stop-wash in gardens, around buildings, and occasionally in coffee and other crops. It is now widely distributed and quite popular for this purpose amongst African cultivators in Buganda, and has a Luganda name, "kalifuwa". It makes an excellent stop-wash for the first year or two, but is now less recommended because experience has shown that after this the lines tend to become gappy by the death of some of the plants. It is also liable to attack by termites.

Vetiver Grass (*Vetiveria zizanioides*).—Like lemon grass, this was originally introduced into Uganda for the extraction of essential oil, and has now found an alternative use as a stop-wash. It has come into favour as lemon grass has gone out, because it does not tend to become gappy and does not appear to be attacked by termites. On account of its smaller size and root spread, it is probably to be recommended for use in plantain gardens rather than elephant grass, in all areas where it is available. This grass is being multiplied and distributed all through Buganda as rapidly as possible. A line grows quickly from root-divisions planted about nine inches apart. When used as a stop-wash it can be slashed down from time to time like elephant grass, and the cut material makes a useful thatching grass. One complaint is on record from a tea estate in Toro that after some time vetiver grass lines had a bad effect on adjacent tea bushes. On another estate where vetiver grass was planted in proximity to tea, this has not been observed; nor has it been noticed in the coffee experiments at Bugusege, where vetiver grass lines have been used.

Indigenous Grasses.—An obvious one to try was the "tete" grass (*Cymbopogon afronardus*), which is available all over the country in large quantity and is of the same genus as lemon grass. This makes a fairly good stop-wash, but even with repeated infilling it is difficult to get the clumps to grow close enough together to form an impervious line. Another grass which was found being used as a stop-wash by a Muganda cultivator and was fairly useful is a large species of *Eragrostis*, known in Luganda as "buyanja". There is no doubt that there are a number of indigenous grasses which would be of more or less use in this connexion.

(*Received for publication on 9th November, 1942*)

Plate 1—Contour line of elephant grass: Ordinary Buganda type

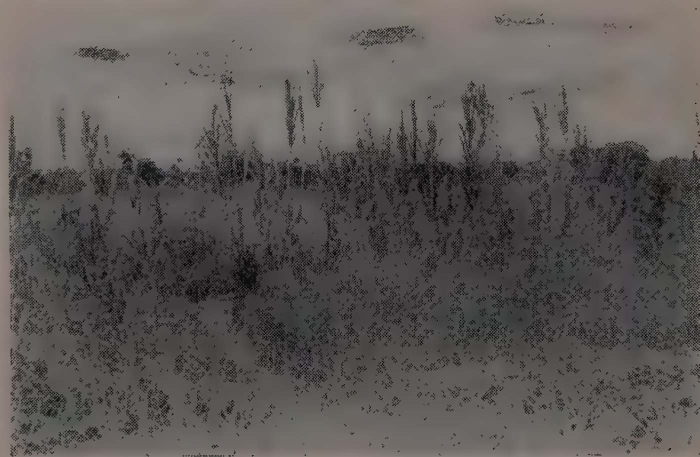


Plate 2—Contour line of elephant grass: "Scrag-necked" type

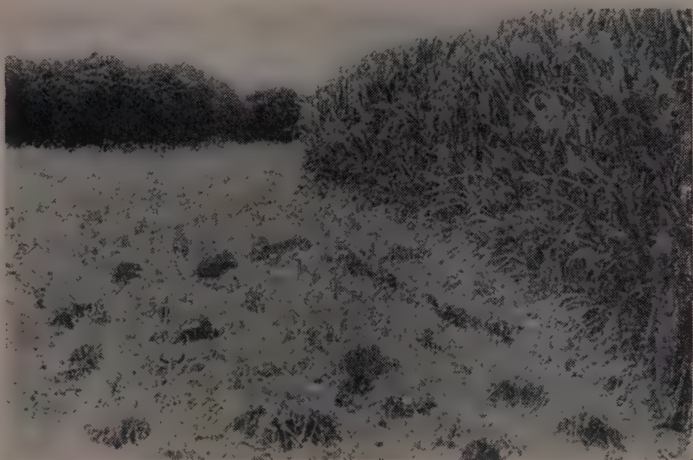


Plate 3—Variation in edge effect: Pyrethrum growing near to elephant grass without ill effect

Plate 4—Variation in edge effect: Pyrethrum in the same field suffering from edge effect

[*To face page* 222

"Pasmo" disease on flax stems.
Natural size

"Pasmo" disease on flax stem showing spore masses extruded from the pycnidia.
× 3 approximately

[To face page 223

THE PASMO DISEASE OF FLAX IN KENYA

(*Sphaerella linorum* Wollenweber)

By R. M. Nattrass, Department of Agriculture, Kenya

During 1941 a serious disease attacked the flax crop in Kenya. It was not until the crop was approaching maturity that it became evident that the flax over a wide area was suffering from a disease not previously seen in Kenya.

The first specimens were sent to me in October, 1941, by Mr. T. W. McClelland, the Kenya Flax Officer, who wrote:—

> "Ten days ago this flax was nowhere near ripe and looked perfectly healthy. To-day when I inspected it the whole crop appeared brown and withered. . . . . I have never seen flax suddenly collapse as it is doing this year."

A microscopical examination of the diseased plants showed, on all the aerial parts, lesions bearing the fructifications of a species of *Septoria* which suggested the "Pasmo" disease, *Sphaerella linorum* Wollenweber. Material and culture of the fungus were sent to the Imperial Mycological Institute, where Dr. Bisby compared the specimens with material of "Pasmo" from N. Dakota, U.S.A., and confirmed the diagnosis.

Flax has been grown in Kenya for many years. During the peak period in 1922 some 26,000 acres were under this crop. The crop declined in subsequent years until, with the present war, flax has once again taken an important place in the Colony's production programme. The acreage in 1941 was about 14,000, rising to over 16,500 in 1942.

The diseases from which flax has suffered during the period are, in order of importance, Rust (*Melampsora lini*), Wilt (*Fusarium* sp.) and Stem Break or Browning (*Polyspora lini*). These diseases are probably world-wide and occur in the United Kingdom, from which country alone during recent years the importation of flax seed has been allowed. "Pasmo" disease does not occur in the British Isles. It is remarkable, therefore, that a sudden and widespread epidemic of this disease should occur in Kenya, where it is believed to be here recorded from the African Continent for the first time. No doubt the importation of linseed from the American Continent has occurred some time or other during the last twenty years. The fungus may have been introduced at any time during that period and persisted unnoticed in a mild form until suitable climatic conditions for an epidemic occurred. It is significant that 1941–1942 was a period of exceptionally prolonged wet periods during which the Potato Blight, *Phytophthora infestans*, first appeared and swept with great rapidity through all the potato crops of the Colony. Conceivably "Pasmo" may have been introduced with recent military and other shipments from America.

The name "Pasmo" or "Spasm", which suggests the sudden onslaught of the disease, is of South American origin and was acquired by the disease in the Argentine. The fungus, which Spegazzini (1911) named *Phlyctaena linicola*, and the symptoms of the disease were first described from Buenos Aires. Girola (1920) drew attention to the considerable losses caused by it in the Argentine and described the disease more fully. In the United States it has been known since 1916, where it is said to have been introduced with imported seed from the Argentine. It was, however, first officially reported from the United States by Brenzel (1923), who stated that ". . . . the disease is very similar to, if not identical with, that found in South America caused by *Phlyctaena linicola* Speg.". The same writer (1924) confirmed the identity of the disease and reported much damage in a number of States, particularly Dakota. Brenzel (1926) later published a full account of the disease in the U.S.A. In recent years reference has been made to the disease in the annual reports of the Canadian Plant Disease Survey.

Pasmo was apparently not observed in Europe until 1936, when it was reported by Rost (1937) as causing heavy damage in Yugoslavia. The following year Wollenweber and Kruger (1938) reported it for the first time from Germany. In Europe the disease does not appear to have extended any further westwards and, according to the latest information, Muskett (private communication), there is no record of the disease having been seen in the British Isles.

Up to 1935 the fungus was known by Spegazzini's name of *Phlyctaena linicola*, the original description given by the author referring to the incomplete upper part of the pycnidium. Brenzel (1926), in describing the American specimens, draws attention to the resemblance of the fungus to *Septoria*, but

maintains the genus *Phlyctaena* on account of the structure of the pycnidium. Garassini (1935), however, in September, 1935, substituted the name *Septoria linicola* (Speg.) comb. nov., and Rost (1937) referred to the fungus as being a typical *Septoria* with black ostiolate pycnidia. In 1938, Wollenweber (1938) found the perfect or acigerous stage of the fungus to be a *Sphaerella* which he named *Sphaerella linicola*, but subsequently (loc. cit) changed to *Sphaerella linorum*, by which name the fungus is now known.

Symptoms of the Disease (Plate)

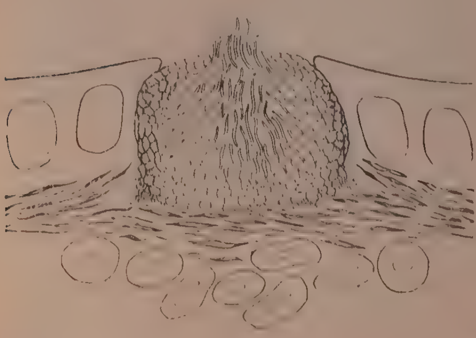
The disease is not usually apparent to the grower until the crop is well on in the flowering stage, when whole areas may suddenly turn brown and become defoliated. Numerous lesions occur on the stems of the diseased plants. They vary in size, frequently encircling the stem and may be two cm. or more in length. All parts of the plant are affected, the lesions extending upwards to the flowering branches and bolls. In a severe attack the lesions coalesce, involving large areas of the stem. The lesions themselves are a darker brown than the ripe straw so that, as they alternate with unaffected parts of the stem, the effect is a characteristic mottled or dappled appearance. Sometimes, when the attack comes on early, the stem is somewhat bleached, which accentuates this mottled appearance.

Infection of the growing crop must usually come from infected straw and other crop debris, the plants being attacked in an early stage, but without, however, suffering much damage. It is probable that the first lesions occur on the cotyledons. On the leaves the lesions are more or less circular and, in the early stages, are a greyish colour, turning later to brown. The leaves themselves also turn yellow as the vascular tissue is affected. No doubt most of the stem lesions are caused by direct spore infection, but the appearance of diseased material suggests that the fungus may also enter the stem by way of a diseased leaf petiole.

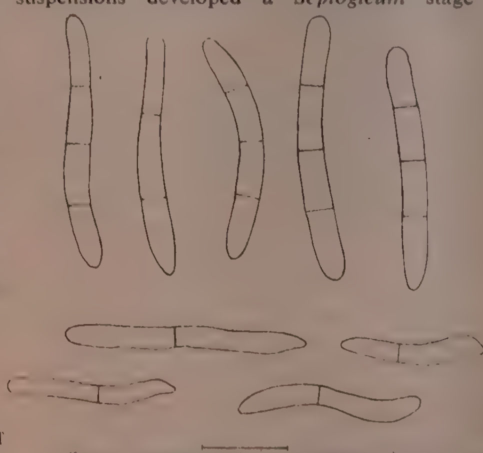
On both stem and leaves the diseased portions are dotted with minute flask-like fruiting bodies of the fungus, pycnidia of the *Septoria* stage (Fig.). These are more or less spherical and are immersed in the superficial tissue, on the stems in the bast fibres and on the leaves below the epidermis. In diameter they measure 70 to 130 mmm. or approximately one-tenth of a millimetre. When young these flask-like bodies open by a small circular pore, but when more mature the opening is larger and somewhat ragged.

The spores (pycnospores) are hyaline, straight, curved or bent, usually 3-septate and measure 25–30 x 2.5–3 mmm. They are extruded from the pycnidia in globular masses or as tendrils, depending largely on the stage of development of the pycnidium. Spores which have been extruded naturally are usually more or less straight or curved. A higher proportion of angularly bent spores occur in the younger pycnidia. In water the spores quickly disperse and so are readily scattered by rain splash from plant to plant. No perfect or *Sphaerella* stage has been found in Kenya.

The fungus grows readily in culture on prune agar. Sub-cultures from mycelium developed a sparse growth of mycelium and few spores. Cultures made directly from spore suspensions developed a *Septogleum* stage



Fruit body (pycnidium) of the *Septoria* stage of *Sphaerella linorum* Wollenweber, from flax stem (diagrammatic) × 250



Spores (pycnospores) of *Sphaerella linorum* Wollenweber from flax stem × 1,300

bearing abundant spore masses but with little mycelial growth. By spraying a suspension of the spores on to nearly mature plants in the greenhouse typical lesions on stems and leaves were produced.

Dissemination of the Disease

During the growing season the disease can spread rapidly by spore distribution when weather conditions are favourable. The extruded spores quickly disperse in drops and films of moisture and are scattered by wind and rain. Under Kenya conditions infected straw and crop debris are the most likely sources of infection. There is little doubt that pycnidia and spores can remain viable from one crop to another. It is stated that in America the seed becomes contaminated with spores (Brenzel, 1926). As many as 560 spores on each seed have been found in a heavy infection. It is not certain that seed transmission is of usual occurrence in Kenya. Seed from a badly infected 1941 crop produced plants without any sign of the disease. The same seeds tested by the "Ulster" method (Muskett and Malone, 1941) failed to produce any growth of the fungus. Similarly the fungus could not be found when centrifuged washings of the same seeds were examined and plated out. The extent to which the fungus may be carried by the seed is the subject of further investigation both in Kenya and by Professor Muskett at the Queen's University, Belfast. It is safest to assume that the disease is here, as elsewhere, carried by the seed. It is clear that small particles of diseased straw, bolls, etc., may carry pycnidia and dried spore masses, and that these may remain with the seed after the cleaning processes.

Control

Crops may be infected either from the remains of a previous crop or from infection carried by the seed. An obvious precaution is to avoid growing flax on land which has carried a crop the previous season, and similarly the longer the interval between two crops the smaller are the chances of survival of the fungus. Further work is needed to determine for how long the fungus will remain viable under Kenya conditions. As has been already stated, no perfect or resting stage of the fungus has yet been found in Kenya, so that there is, at present, no reason to anticipate a long survival period.

It is important that seed from an infected crop should not be sown, especially on land free from the disease. The movement of both seed and straw from infected areas should be controlled and fresh outbreaks should be immediately notified.

All authorities are agreed on the value of field sanitation as well as crop rotation as control measures. It is recommended that straw and stubble in the case of linseed, and crop debris where flax is produced, should, if the crop is known to be infected, be burned, ploughed in deeply or otherwise destroyed. The development and spread of the disease is very dependent on weather conditions. In certain seasons no infection of the crop may follow planting on contaminated ground or the use of infected seed.

Control of the seed-borne disease can only be accomplished by a suitable form of disinfection. Earlier writers recommended the wet treatment with formaldehyde solution as for the control of *Fusarium* wilt. Rost (1937) states that in Germany disinfection of the seed by fungicidal dusts proved ineffective. The whole question of the control of Pasmo by treatment with organic mercurial and other dusts is receiving attention by Professor Muskett, who has been supplied with material and cultures from Kenya. These investigations are still in progress. For the time being Professor Muskett recommends treatment of the seed with Agrosan, as used for cereal disinfection, by the "fixation" method. This consists of treating the seed with the dust at the rate of 12 ounces to the hundredweight and then "fixing" it to the seed by slightly wetting it with water as in the "short-wet" treatment. An alternative is treatment with a liquid fungicide, Ceresan U. 564, at a strength of 8 per cent in water, also applied by the "short-wet" process.

In the "short-wet" process, evolved by Professor Muskett and his colleagues, the liquid is applied at the rate of three-quarters of a gallon to a hundredweight of seed. This small amount of liquid is not sufficient to cause swelling of the seed mucilage and consequent sticking of the seed together, altho gh there may be a tendency for small clumps to occur. These, however, readily break down when the seed has dried. Provided the seed is reasonably dry to start with there is no need specially to dry the seed; it will dry quite well in the bag. Seed treated by either method should not be stored for longer than three months.

The two varieties of flax, Liral Crown and Stormont Gossamer, now grown in Kenya appear to be equally susceptible to the disease. Other varieties are known to be resistant. Brenzel (1926) says that some of the Dakota selections are very much more resistant than the Argentine selections. It may be possible by selection to obtain resistant strains from the two varieties at present in cultivation in Kenya.

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REVIEW

Elementary Forestry: A First Text Book for African Forest Rangers, by W. J. Eggeling, B.Sc., Ph.D., Senior Assistant Conservator of Forests, in collaboration with the European Staff of the Forest Department, Uganda.

Although a note at the beginning of this book states that it is primarily intended for use in the Forest Rangers' School at Ikelwe in Busoga, for students who have completed a full Secondary or Junior Secondary Education of their equivalent, it is one that should be on the book shelves of farmers as well as of all those interested in forestry.

It contains some 166 pages, including an index, and 31 figures, besides those scattered through the text. The nine parts into which it is divided cover Forestry, Soil, Simple Botany, Demarcation and Survey, Protection, Management and Exploitation, Silviculture, Administration, concluding with "Useful Information", a glossary of common and vernacular names, and a very complete index.

"Silviculture" is divided into five sections: regeneration; nursery work; formation, i.e. choice of species, site selection, clearing, draining hoeing, pegging, pitting and mounding spot-sowing and planting; tending and notes on the silviculture of some important species. These subjects cover twenty-one chapters and contain much useful information on nursery practice, plantation work and management.

The species treated specially are "Muvule", Mahoganies, Eucalyptus, *Cassia siamea*, "Nsambya" and "Wattle". As in the other sections of the book, when only the native names had been used in the text, the reviewer, not living in Uganda, had to hunt in the glossary of common and vernacular names for the scientific names of the species. It is a pity that authors in East Africa on agricultural and forestry matters are so parochial. By the use of native names, many purely local, they write as though the rest of the world were not at all interested in what we in East Africa were doing. It would have been just as easy to use the scientific name, as the author has for *Cassia siamea*, or else indicate them as he has done under Mahoganies and Eucalyptus. "Wattle" is another undesirably vague term used.

Part IX, "Useful Information", contains many valuable items of interest to the planting community, such as weights and measures tables, the firewood-carrying capacity of lorries, amounts of fuel required for brick-burning, fuel consumption of ginneries, concrete and cement-plaster mixtures, fuel yields from plantations, number of trees per acre square planting at various planting distances, approximate numbers of certain tree seeds to the pound, volume tables, and wages tables from Sh. 6 to Sh. 20 per month. There is also an account (p. 53) on charcoal making, with a diagrammatic drawing of a section through a two-tier charcoal kiln.

Dr. Eggeling, the European staff and the Forestry Department are to be congratulated on the production of this very useful book. Its price, Sh. 2/50, from the Forest Department or the Government Printer, Uganda, does not put it beyond the reach of the educated African or those of us who are interested in forestry matters or plantation management.

In spite of the war and a shortage of paper, one hopes that this book will encourage others who are interested in the agriculture and animal husbandry of East Africa to emulate the members of the Uganda Forestry Department and produce similar text books dealing with their respective subjects. P.J.G.

NOTES ON AGRICULTURE IN ETHIOPIA
Part 2

By Major F. de V. Joyce, M.C.

The practice known as "shifting cultivation" is used where there is room. The dividing line between the much-abused practice of "shifting cultivation" in Africa and the much-commended one of "grass leys" in Europe is a fine one and I see no reason for condemning the former as applied in part of this country. It is remarkable that one of the chiefs I talked to, who had spent some years in Italy as a prisoner, had noticed that there was no room in Italy for shifting cultivation and had been much impressed by their standard of farming.

In many parts of the country two crops are grown per year, often one grain crop and one bean or pea crop.

Cereal Crops

In the high country, 7,500 ft. or over, the main cereals grown are:—

Wheat, barley and tef (*Poa Abyssinica*).* This latter is, I believe, the same as the tef grass grown as a forage crop in South Africa. The grain is very small and makes a fine grey flour and is the favourite food of those who live where it can be grown.

Oats are grown occasionally for forage but more often occurs as a weed among the barley or wheat.

At the lower altitudes millet predominates. There are many varieties of these sorghums, some up to 10 ft. high and yielding immense crops which I estimate up to 10 bags (of 200 lb.) per acre. Maize is grown in relatively small quantities, is planted very close and the grain is small. Its comparative absence must be a matter of choice and taste only, for undoubtedly all the large areas now under millet could grow equally good maize.

Yields of wheat and barley vary from two to seven bags (of 200 lb.) per acre. The grain is not very plump and is rather mixed. Seventy per cent of the wheat is said to be of the "hard" varieties. I saw no rust or other disease in the wheat or barley and do not recommend the introduction of new varieties now. If the farmers could be taught to do something about seed selection, by winnowing out the largest grains and using there for seed, they would improve their yields.

Leguminous and Other Food Crops

These include broad beans, French beans, two types of chick peas, field peas, lentils, groundnuts and, for edible oil, linseed, Niger seed (*Guizotia abyssinica*), sesame (*sim-sim*) and sunflower (in small quantities).

Near Harar I saw a small oil mill producing oil from groundnuts grown in that province and this has a ready market for native use. The cake resulting from the process was of first-class quality and was being used as fuel for the factory's steam engine!

If this oil mill is kept in use, I suggest some enterprising Ethiopian near Harar might be persuaded to start a small dairy farm with 20 or 30 good native cows and try the effect of feeding this cake on their milk yields. He would get a ready market for this milk in Harar and could probably get the cake in exchange for firewood.

In some of the lower areas round Jimma and Dalle, and no doubt elsewhere, a type of banana known botanically as *Musa Ensete* not only provides a very useful fibre for cordage but a flour is made from the roots and lower parts of the plant.

Fruit and Vegetables

Harar is the main centre for these, both due to its altitude of about 5,500 feet and its plentiful water supply for irrigation.

Potatoes are said to be plentiful there, though I saw very few either there or in any other part of the country. They would do well over a wide range of country and seed should be distributed. They will vary the diet, and, being locust proof, are an added safeguard against famine.

In most parts of the country the peasant farmer grows a few vegetables for his own use, chiefly tomatoes, onions, cabbages, and chillies. The latter are of the very hot variety; they are an essential part of the Ethiopian's diet and are obtainable in any native market, ground to a fine powder. Incidentally they contain a high proportion of vitamin C.

All European vegetables grow well and the various market gardens which were worked by Italians near the towns should be maintained by Ethiopians.

Fruit is disappointing, especially the European varieties, with the exception of strawberries. Citrus fruit of all kinds could and should be grown; it has a high nutritional (anti-scorbutic) value and those citrus trees planted by the Italians should be maintained and others planted; but I suggest that apples and pears be discarded.

* The correct name is *Eragrostis tef*.—P.J.G.

Much fruit could and should be grown for the towns on the small farms in the vicinity. Addis Ababa could be supplied with considerable quantities from the Mohamed Ali Farm near the aerodrome and from Akaki, and these should be leased to some enterprising horticulturist.

Various spices and herbs are grown or grow wild and are used by the natives in cooking: ginger, cardamom and wild thyme were the only ones I came across, but there are many others. Further reference will be made to these under the general heading of "Plantation Crops".

Plantation Crops

In this group there are great possibilities for expansion, especially for export as, generally speaking, their high value enables them to stand high transport costs.

I will include in this group coffee, tea, cocoa, rubber, cotton, tobacco, hemp, sugar, pyrethrum and "drug plants".

Coffee

The annual exports for the 10 years ending 1934 averaged about 15,000 tons, half of which came from Harar Province. Rather more than half of the exports passed eastwards through Djibuti and most of the balance went westwards to the Sudan. The industry is therefore a considerable one and in spite of reputed world over-production I believe Abyssinian coffee exports could be increased. It is to be hoped that after the war better methods of world distribution will be evolved, and, apart from this, the low grade imperfectly prepared type of native produced coffee has a special market of its own. The Sudan, and especially Egypt, take large quantities, and I look to an increase in coffee consumption in other parts of Africa by Africans and for this market the Abyssinian peasant planter with a few trees is eminently adapted.

I do not think it will be feasible for many years to come to improve the peasant methods of preparation of the bean by centralized pulpers or hullers. I saw coffee in Jimma, Caffa, Harar and the edge of Arussi in the lakes area.

All small plots looked uncared for but healthy and were often planted as close as 3 feet × 3 feet, sometimes in dense shade. In Chercher, between Deder and Irna, on very steep hillsides, the coffee was often bench-terraced and always planted on the contour. This also applies to the considerable acreage of "khat" in the same district.

At Fadis, some 15 miles south of Harar, there is a plantation of some size on the property that used to belong to the Simba Co. This is in black-cotton soil and is irrigated. When I visited it, so wet was the ground that it was difficult to walk through. This coffee suffered to some extent from die-back, but I saw no sign of mealy bug or other pest or disease. The largest plantation I visited was one of about 200 acres, east of Lake Awasa, some 20 miles north-east of Dalle. This belongs to a Belgian, M. Colaris, who unfortunately was away at the time. No steps appear to be taken to control wash and some of the slopes planted are steep. No manure, artificial or otherwise, appears to be used. The method of preparation of the bean is worth recording and is as follows:—

Pick when red if labour permits, otherwise a good deal of already dried bean is picked with the red cherry. This is then spread out on a large earth barbecue and turned daily till all is dry and brown. This takes up to 15 days. It is then put through a circular stone flour mill with the stones set far enough apart to crush only the dried husk, leaving the green berry.

The berry looks small and uneven but of good colour and a cup of coffee I was given there by the owner's Italian overseer is one of the best I have drunk in any country. I am taking a sample of this to Nairobi for detailed report.

I recommend that small coffee nurseries of selected seed be established at a number of small centres (where there is a local sub-chief to be responsible) in Chercher, Jimma, Lechemti, Gojjam and especially Caffa areas, and that all peasants in those or other suitable areas be given some 20 or 30 trees and made to plant them out and look after them.

Tea

I saw two small experimental plots only; one near Jimma, at the Italian experimental farm, where the trees had grown to a height of five feet in two years time, had not been pruned and appeared healthy, and the other at the Mission Station at Bonga, where the trees were 12 feet high, of unknown age, also unpruned and apparently healthy.

I believe there to be large areas in this country, more particularly in the Jimma–Bonga–Gore area, where climate and soil conditions would suit tea, if not of the highest quality, at least of the lower grades, for which

there appears to be a very large and growing market among Africans.

I advise therefore that as soon as possible a tea expert be engaged to make a survey of this area and report. If his report is favourable and seed is obtainable, nurseries should be established and after the war invitations be issued for development of tea plantations. This is eminently a crop for large-scale company production and could not be successfully undertaken by peasant farmers.

Cocoa

I have seen none, but from a study of rainfall and temperature conditions it would appear that some areas on the "Sudan Slope" were suitable for this crop.

Rubber

As mentioned before, under "Forests" there is some indigenous rubber-bearing forest in Ethiopia. I think, however, it would be preferable to develop plantations of para rubber (*Hevea Brasiliensis*) and for this purpose expert advice should be got on the same lines as for tea. I understand that the Italians established an experimental plot at Bure, about half way between Gore and Dembidollo. The rubber expert would not have to cover a large area of country and could accompany the tea expert over approximately the same area.

There should be a great demand for rubber after the war, especially in view of the damage done to existing plantations in the Far East. Ethiopia herself is said to be capable of consuming a considerable quantity for shoe soles, and this question of rubber development should be followed up now.

Cotton

The imports of raw cotton, cotton thread and cotton piece-goods into Abyssinia are very large. The available figures are somewhat confusing, but the total amount appears to have been about 7,500 tons per year before the Italian occupation.

Italy had all sorts of ambitious schemes for stimulating production in Ethiopia, but these were based on the object of making Italy and her Empire as self-supporting as possible, rather than on sound economic development.

In view, however, of Ethiopia's indifferent communications and immense consumption of cotton, and the large exports required to balance the import of cotton, it must be sound policy to stimulate local production, provided this be not done at the expense of the land.

The Italians had established ginneries at Alomata, Adama, Sodhu, Lechemti and Diredawa, and at this latter place had erected a large spinning and weaving mill, capable, I was told, of a maximum production of 9,000 metres of cloth per day, which was said to be one-fifth only of the local consumption. On examination it looks as if these figures are about right. All Ethiopians wear cotton, and allowing man, woman and child only two yards per year of imported cotton, requires 16,000,000 yards per year or about 45,000 yards per day.

Incidentally, this Diredawa factory only got a fraction of its requirements locally and used to import raw cotton from India, Iran and elsewhere. The unbleached cloth produced is of very good quality.

Cotton has always been grown in small patches all over Ethiopia at suitable altitudes and is spun and woven into coarse but useful cloth by the country women. This should be encouraged in every possible way. Every yard of this home-made cloth should save the import of at least a yard of imported material, and I believe it might be possible to stimulate this home industry by the introduction of a better type of hand loom.

Apart from this, the "Sudan Slope" area appears to offer conditions suitable for growing short staple, non-irrigated cotton as in Uganda. One of the difficulties of this type of cotton is that the picking period extends for some three days only and therefore requires a considerable amount of labour. Whether that would be available to the peasant cotton grower in the area referred to I do not know. I suggest, however, that a cotton expert be added to those referred to under tea and rubber to explore and report on the same general area. If it proves possible to establish cotton growing on a large scale, the raw cotton should be converted into cloth in this country both by hand and, if necessary, by a mill of the Diredawa type, which would be better situated at Addis Ababa.

Tobacco

Tobacco is grown in small plots in many of the lower parts of the country. At Amaresa near Harar I saw some good sun-dried, bright tobacco grown by an Italian. The Ethiopian Government might well try and get a Greek to take this over and generally to see if the development of a good type of tobacco could not be started. I also suggest they get in touch

with the large tobacco firms who have done so much to develop the native tobacco industry in other parts of Africa and who would readily seize the opportunity to do so here, after the war, if conditions and prospects were favourable.

Fibres

The best local fibre for cord and sack-making comes from the peculiar banana known as *Musa Ensete*.

Where this is grown and there is no factory, the natives know the technique of decorticating it by hand. They bring it to a cord factory where such exists. This industry should not be allowed to collapse. The *Musa Ensete* also supplies a form of flour and therefore will continue to be grown. A simple cord factory exists at Jimma, and at Addis Ababa there is a large modern sack factory which turns out a useful type of hessian and sack from this indigenous fibre.

As the imports of sacks amounted to about 500 tons (say, half a million sacks) annually for the 10 years up to and including 1934, any reduction in these imports by the locally produced article should be encouraged.

It is not worth considering growing exotic fibres, such as sisal, or using other indigenous ones as sansivera. The great advantage of *Musa Ensete* is that it supplies food as well as the means of packing it.

It has been suggested that flax for fibre might be grown in Ethiopia. This crop requires skill and care in preparation as well as much machinery. The price now is artificially high, but I do not think it feasible to establish this crop now for war supplies. It would, however, be worth encouraging its use for local spinning and weaving in the high-altitude zones. The linseed they now grow would do well to start on, though it might be difficult to persuade the peasants to sacrifice the grain crop for the fibre.

Sugar

Very little is grown and the country depends on imports, which, prior to the Italian occupation, averaged about 1,500 tons annually.* There is a sugar cane plantation north of Mogadiscio, in ex-Italian Somaliland, but this probably does not supply the needs even of that country. Cane sugar is essentially a plantation crop and there are undoubtedly areas in this country where it would grow. Amongst others I suggest (*a*) the low valley at about 4,500 feet altitude from a point about 20 miles south-east of Combolcia, on the main Dessie–Addis Ababa road, (*b*) the reaches of the Awash valley near Adama, and (*c*) the low-altitude, high-rainfall area on the Sudan Slope.

There is said to be 750 acres of sugar cane at Wongi, 10 miles from Adama, but I did not see it.

Sugar beet should also be considered. It should grow admirably in the heavy black soils of the uplands. I was told that the Italian Government had carried out very successful experiments with it, but was unable to discover where.

Sugar beet could be produced by peasant farmers situated round a central factory. I doubt, however, whether such factory for a small output of a few thousand tons a year would be an economic proposition.

The aim should be to produce enough for local consumption only. Large amounts of cane sugar are produced in the adjacent territories of Kenya and Uganda, and if good and cheap transport facilities are re-established between Mombasa and Jibuti after the war it is quite possible that the local production of such a small amount would not be worth while.

Pyrethrum

Pyrethrum would undoubtedly grow well in much of the high country. This crop requires very careful growing, picking, treatment and much hand labour. The mechanical driers, which are essential, consume large quantities of fuel which would first have to be grown. The market is not simple and showed signs of being glutted in 1940.

I do not think the Ethiopian timber resources or temperament are suitable for this crop and consider that any attempt to develop it will only result in disappointment.

Drug Plants

This should be one of the most fruitful fields for development. There are always areas of the country in the warmer districts where rainfall (both in quantity and distribution), temperature and soil conditions should suit. Usually the products are of such high value that transport need not be seriously considered. I include in the above category any valuable spices, indigenous or otherwise, that might be grown.

(*To be continued*)

* There is some doubt about this figure, which possibly should read 15,000 tons.—F.V.J.

THE PRODUCTION AND PREPARATION OF RUBBER IN UGANDA

By A. S. Thomas, Executive Officer and Chairman, Rubber Production Committee, Uganda

Early History of Uganda Rubber

Uganda is not a great rubber-producing country. At the end of the nineteenth century, when the exploration of the resources of the Protectorate was in active progress, there was a great demand for rubber and, when it was found that rubber-producing vines (*Landolphia* spp.) were common in some parts, this fact was considered of such importance that Sir Harry Johnston, the special Commissioner in 1900, referred to rubber as "what I believe to be the production of the surest value to the Uganda Protectorate". Wild rubber was in such demand that a search for plants from which it might be produced was the main reason for the botanical mission made by Dawe in 1905; during this mission he travelled over 3,000 miles, mostly on foot, inspecting the forests in the south and west of Uganda, from Entebbe down to the Tanganyika border, and then northwards through Ankole, Toro, Bunyoro and the Acholi country to Gondokoro; the journey took over eight months. His report (Dawe 1906) provides a most excellent survey of the resources of the forests, both of wild rubber and of timber.

It was found that, if the tapping of the wild rubber vines was left to Africans, the plants were soon killed out; therefore concessions to tap in the forests on the islands in Lake Victoria were granted to an Italian company in 1902, and a concession to tap in the forests in the Masaka district was granted to a German company in 1903. But neither of these areas yielded much rubber, the maximum annual production being about 6,000 lb. and the concessions were given up after a few years.

Many plants of potential economic value were supplied from the Royal Botanic Gardens, Kew, to the newly founded Botanic Gardens at Entebbe at the beginning of the twentieth century, and among them were some rubber-producing species of trees—*Castilloa elastica, Funtumia elastica, Manihot glaziovii,* and *Hevea brasiliensis*. After the seedlings of *Funtumia elastica* had been received, it was found that the tree was indigenous, and it is from this species that the greater proportion of wild rubber exported from Uganda has been derived. The peak year of export of wild rubber from Uganda was 1910, when about 100,000 lb. were sold; 80,000 lb. of this total was *Funtumia* rubber from the Mabira Forest. The total amount of wild rubber exported from the protectorate was very small in comparison to the exports from other African territories; for example, the maximum annual production from the Gold Coast was 5,000,000 lb. and from the Belgian Congo 13,000,000 lb.

Plantation Rubber

Much attention was paid to the exotic rubber plants in the Botanic Gardens by the Forestry and Scientific Department and by the pioneers of the European planting industry. *Castilloa* was little planted; *Funtumia* was tried on a small scale as a plantation crop; for some time, opinion was divided on the relative merits of Ceara rubber (*Manihot*) and Para rubber (*Hevea*); over a thousand acres of Ceara rubber were planted, but it soon became evident that Para rubber was the more profitable crop and attention was devoted almost exclusively to it. The main expansion of rubber estates was between 1910 and 1920; in 1910 there were about 1,400 acres under the crop; in 1920 there were about 14,000 acres. Most of the rubber estates were in the Mengo district, north of Lake Victoria, but smaller areas were planted in the Bunyoro district, south-east of Lake Albert, in the Busoga district, east of the Nile, and in the Masaka district.

Large amounts of European capital were sunk in these estates at a time when the price of rubber was high, but the results were disappointing. It was found that it took about eight years for the trees to attain a size fit for tapping, and that the average yields were low. Few estates could maintain a steady annual production of over two hundred pounds of dry rubber per acre. The bark was thin and hard, so that thick parings had to be taken; both the initial growth of trees and the regeneration of bark were slow; the rate of consumption greatly exceeded the rate of renewal. The great production of rubber in the East, where yields were so much heavier, led to a drastic fall in prices before many Uganda estates came into production and a great deal of the money invested in the estates has been lost.

The climate of Uganda is tropical in comparison with that of the higher areas of East

Africa, but is much cooler and less humid than that of the main rubber-producing countries. The Uganda rubber estates are situated in areas where the average rainfall is only 50 to 55 inches but is very well distributed. It seems that temperature, rather than rainfall, is the main limiting factor to the growth of rubber; for the average temperature of the air at Kampala is 69° F., as compared with an average temperature of 75° F. in Malaya. At Masindi the average temperature, 71° F., is slightly higher than that of Kampala and the condition of the rubber in this neighbourhood is much better than that of the rubber near Kampala; the trees have a better canopy of foliage, the leaves not being severely attacked by leaf disease (*Oidium*), the bark grows more quickly and the yields are higher.

Low yields of rubber in Uganda seem to be mainly due to low temperatures, but the poor strains of rubber planted also appear to be partly responsible; for most of the trees have an erect branching habit very different from the whorled, spreading habit of many high-yielding clones in the East. It is possible that soil factors also are involved; most of the soils in Kyagwe are heavy loams and are less acid than those on which rubber is grown in Malaya, and it may be that they do not really suit Para rubber; one estate in Uganda, whose yields have been exceptionally good for this country, is on a more acid, sandy soil.

When prices of rubber have been high, Uganda estates have been in production; but during the slumps the prices have not covered the costs of tapping, preparation and packing and it has been necessary to cease all work on the rubber. Planters have turned their attention to other crops, such as Robusta coffee, which are more suited to Uganda conditions. Much of the rubber was weeded and planted with Robusta coffee; other areas, which were not thus interplanted, were abandoned and became covered with a dense growth of forest plants or grasses; fires swept through many of the grass-grown patches, scorching the bark and killing many of the rubber trees. Considerable areas of Para rubber were cut down to be used as fire-wood or to make room for other crops. The price of rubber rose in 1935 and 1936 and most estates went into production again, although the revenue derived from the rubber barely covered the cost of preparation and gave little margin to cover overhead charges or the interest on capital. Little or no cultivation was given to the plots which contained rubber alone; the undergrowth was slashed only along the lines of trees to allow the access of the tappers.

Difficulties of economical production were increased by the manner in which the rubber had been planted, in relatively small areas of usually only one or two hundred acres, on separate estates at some distance from each other. The scattered distribution of rubber made supervision very difficult after the fall in prices had made it necessary to reduce the European staff to a minimum; and it was impossible to adopt the methods of modern centralized factories with their coagulating tanks and batteries of rollers. Uganda rubber factories have coagulated the latex in dishes and used two or three hand rollers; but nevertheless they have turned out first-grade rubber. Even less economical than the European estates were the small blocks of rubber planted by Africans, blocks of a few acres which have seldom been tapped by their owners, although some of them were at times leased by producers on estates near them.

At the beginning of 1942, when the loss of Malaya created an urgent demand for rubber, there remained in Uganda about 10,000 acres of Para rubber; there were about 9,000 acres in the Mengo district, about 1,000 acres in Bunyoro, about 250 acres in the Masaka district and only about 30 acres left in Busoga. The bulk of this rubber had been planted before 1920 and the trees had passed their prime. There were only a few hundred acres of young untapped trees, for the relatively low prices of recent years had offered no inducement to the planting of more rubber in Uganda; and there had been no question that it would be worth while to dig out blocks of old trees and to replant the ground with more high-yielding material, as has been done on a large scale in the East. Most of the better estates had been tapped for several years and supplies of bark suitable for tapping were almost exhausted. But it is obvious that the rubber estates of Uganda were a potential source of supply much more important than the wild rubbers. Attention therefore was devoted first to attaining maximum production on estates, then to the *Funtumia* trees in the forests and finally to the vine rubbers. Little attention had been paid to the wild rubber for the last thirty years, although small amounts of *Funtumia* rubber had been collected at times of very high prices.

There have been difficulties to be rectified on estates; producers suffered from shortage of cash to be expended on reclamation and development, from shortage of labour and from

shortage of equipment. The shortage of ready money has been remedied by a scheme whereby the Rubber Production Committee (which was set up to stimulate rubber production) act as agents for the Ministry of Supply and the producers receive payment for their rubber as soon as it has been railed, instead of waiting for many months until it has been sold. In cases where money was very urgently needed, interest-free loans were made and are being repaid by deduction from the value of rubber sold. The shortage of labour has been greatly diminished but there is still some difficulty on a few estates owing to a high proportion of absenteeism among the tappers; regular tapping is essential if the maximum output it to be attained. Shortages of equipment have been remedied by the use of locally made substitutes. Coagulating trays made out of mahogany have proved satisfactory. Locally made tapping knives, while not so good as those imported from England, enabled the number of tappers to be greatly increased before imported knives were again available. Even locally made rollers have been tried, but they are not strong enough for any but the preliminary rolling. In the case of small outlying patches of rubber, sometimes the latex has been brought into existing factories by bicycle and sometimes it has been coagulated, the bulk of the serum rolled out by hand, and the rubber transported in the form of half-prepared sheets to factories where the rolling may be finished and the sheets dried and smoked.

Para rubber trees on Uganda estates are tapped by a half cut on alternate days or by some corresponding system, such as quarter cut every day or by a half cut every day for six weeks and then resting for six weeks. Under the local conditions, any more drastic system would amount to slaughter tapping, a procedure which is being adopted on some estates where it is intended to kill and remove all the rubber trees at the end of the war. Even on estates where it is intended to retain some rubber, it will be better to slaughter-tap and root-tap all the very poor-yielding trees, and to remove them in order to allow more root room for the trees which are being retained; root competition for soil moisture appears to be severe under the relatively dry climate of Uganda, and is intensified when the rubber is interplanted with Robusta coffee.

Acetic acid has been the coagulant most used in Uganda. Shortage of supplies has been mitigated by using a portion of serum to coagulate a second batch of latex. The acid can be made locally in a strength up to about 5 per cent by a process worked out by Hansford and Martin (1943); if the local banana beer is kept for a few weeks it becomes sufficiently acid to be used as a coagulant. And it has been found that a dilute solution of sugar, made up one day and added to latex the next, will coagulate it. Molasses, which is available in quantity as a by-product from the local sugar factories, may also be used: if diluted with eight times its volume of water, allowed to stand for a day and added to standardized latex at the proportion of 1 oz. to two quarts of latex (equivalent to about $\frac{3}{4}$ lb. of rubber), it produces complete coagulation. Sheet rubber prepared with sugar or molasses solution is sometimes bubbly, but that does not mean that the value at the present time is much affected, provided that the rubber is clean and dry.

There is little Ceara rubber left in Uganda, less than one hundred acres, but it is now in production. Under relatively moist Uganda conditions there is a free flow of latex when the trees are tapped; the rough outer bark of the trees therefore has been scraped off and the soft inner bark has been tapped on the herring-bone system at intervals of three days (Plate 1). It has been found that more frequent tapping, either daily or on alternate days, does not give an increase in yield to compensate for the more rapid consumption of bark. If the trees are tapped on the half spiral system with a single cut, as in the case of Para rubber, there is only a very small flow from each tree and therefore it is necessary to use a number of cuts on the herring-bone system. The latex may be coagulated even more easily than that of the Para rubber; dilute acid may be used or the latex may be simply mixed with water and allowed to stand overnight. The sheets of rubber are rolled and smoked in the same way as those of Para rubber.

Funtumia Rubber

Two species of *Funtumia* grow in Uganda. One of them, *Funtumia latifolia*, is a medium-sized tree, widespread in the wetter forests of the south and west of the Protectorate; its latex is copious but quite useless for rubber production, coagulating into a sticky mass which may be used as birdlime. The other species, *Funtumia elastica*, which yields good rubber, is more restricted in its distribution but is abundant in the Mabira Forest in Kyagwe and in the Budongo and Bugoma Forests of Bunyoro. *Funtumia elastica* resembles *Funtumia latifolia* in appearance; it is usually rather smaller in size and grows in

drier situations; the easiest way to distinguish between the two species is to rub a little of the latex between thumb and finger; from *Funtumia elastica* a small mass of rubber will be formed; leaving the skin clean; from *Funtumia latifolia* a very sticky coagulum, closely adhering to the skin, will result.

Exploitation of the *Funtumia* rubber in the forests is not an easy task. *Funtumia elastica* is not evenly distributed throughout the forests: in some areas it is relatively abundant, in other areas the trees are much fewer and the species is absent from large tracts of the forest. This absence is especially noticeable in the parts where the forest has reached its climax and *Cynometra Alexandrii* is the dominant tree. The average concentration of *Funtumia elastica* in the Mabira, Budongo and Bugoma forests

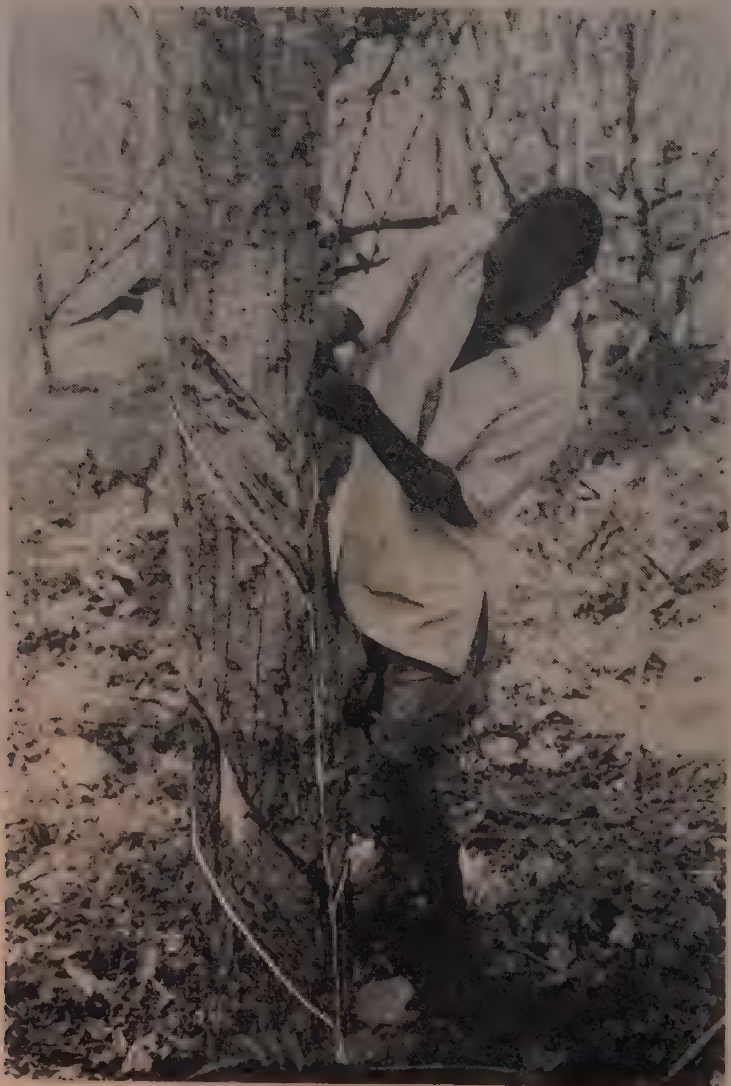

Plate 1—Ceara rubber being tapped on the herring-bone system

appears to be about three trees per acre. If the forest is to be worked systematically, roads and tracts must be cut to divide it up into sections. Care must be taken that the labourers are adequately housed, for it is very wet in the forests at some seasons; no food supplies are available there and arrangements must be made that good rations are delivered at the camps, a matter of some difficulty when there is a shortage of foodstuffs. Many labourers do not like working in the forests and it is not easy to find ones who will climb trees; for, if the maximum production is to be achieved, the trees should be tapped to a height of twenty feet and, on account of the density of the undergrowth, it would be difficult to carry ladders about in the forest.

The latex of *Funtumia elastica* is contained in vessels much wider, longer and less branched than those of *Hevea;* the trees are tapped on the herring-bone system to as great a height as possible and there is a rapid, copious, flow of latex, so that by the end of about fifteen minutes the bark has been drained. Yields vary greatly from tree to tree, but the average from the large trees seems to be about half a pint of latex, corresponding to about one-quarter of a pound of dry rubber. This is lower than the figure of half a pound per tree which was put forward by Christy (1911). Christy claimed that even heavier yields were to be obtained by cutting down a tree, chopping it into short lengths and draining them; but recent experiments have shown that this method gives smaller volumes of latex than are to be obtained by normal herring-bone tapping. It has been found that it is not worth while to tap the trees more than twice a year, a fact which greatly increases the cost of collection as, in order to maintain production, the tappers most continually shift into fresh areas of forest and long lengths of path must be cut. In order to economize labour, the trees are now being tapped by two herring-bone cuts on opposite sides. The tappers usually work in pairs, one of them carrying a covered bucket in which the latex is carried to the collecting centre.

Even when the latex has been brought into the factory the difficulties of *Funtumia* rubber production are not ended, for the latex is very troublesome to coagulate. It may be kept for months before it will coagulate spontaneously, forming a dark grey mass which is difficult to work and to dry. It is unaffected by acetic or formic acid, such as coagulates the latex of *Hevea.* Tannic acid and mercuric chloride are said to be good coagulants, but they are not available in quantity at the present time. Formalin produces quick coagulation, forming a sheet which looks well at first, but it soon becomes hard and loses its elasticity; nevertheless, reports on samples prepared in various ways have shown that formalin-coagulated sheet has much better physical properties than sheet rubber prepared in other ways. Unfortunately, this coagulant cannot be imported in large quantities at the present time. Alcohol coagulates the rubber quickly, but so much is required to make a pound of rubber that its use is not economic.

Funtumia latex is coagulated when poured into boiling water, a method which is frequently used. It has been found that if a pint of latex is poured into water boiling in a shallow pan—a *karai* or mortar pan is suitable—it coagulates fairly quickly and, if the coagulum is taken out while it is hot, it may be rolled out into a sheet. The latex froths considerably; one man should stir all the time and another should sprinkle cold water on the froth to control it; if a little alum is added to the water the coagulation is hastened and frothing is controlled; an infusion of wattle bark or of the leaves, fruits and bark of *Bauhinia thonningii* will act in the same way. A modification of the boiling method is now used. One quart of *Funtumia* latex is poured into a coagulating dish and two quarts of a boiling dilute infusion of *Bauhinia thonningii* leaves and bark is added. The latex coagulates quickly and, as soon as it is cool enough to handle (which is quite soon, as the African is able to grasp things far hotter than a European can bear to touch) it is rolled out into a sheet. Not only is it hard to coagulate *Funtumia* latex, but also the sheet rubber is more difficult to dry. Drying does not appear to be greatly accelerated by the use of a smoke and it has been found that it may be done fairly quickly by hanging the sheets in a shed with open sides, through which a good current of air may pass.

In spite of the difficulties of *Funtumia* rubber production, it is hoped that by intensive working of the forests—over a thousand men are now engaged in the exploitation of the Mabira Forest alone—and by drastic tapping there will be a substantial production during the next eighteen months or two years. At the end of that period it is hoped that all readily accessible trees will have been drained of latex; the *Funtumia* trees will suffer in the process but, as they are of little or no value for timber, their loss will not much diminish the value of the forests.

Vine Rubber

The main rubber-producing vines of Uganda belong to two genera of the natural order Apocynaceae—*Landolphia* and *Clitandra*—which closely resemble each other in habit, but may be distinguished by the fact that the flowers of *Landolphia* are borne in clusters at the end of the shoots, while the flowers of *Clitandra* are borne in axils of leaves, like those of coffee.

The best of these vines for rubber production in Uganda appears to be *Landolphia dawei*, a large vine which is abundant in the forests near the lake shore in the Masaka district, on the islands in Lake Victoria, and which has been reported from forests in other parts of the country. There are some men still living who were employed as tappers of the rubber vines in the forests of the Masaka district thirty-five or more years ago, and they state that this vine, which is known locally as *nansale*, is the most abundant of the rubber vines in those forests. When concessions were exploited, rubber prices were high and several Europeans were employed to supervise the work; hundreds of tappers were employed to go into the forests and to bring the latex to collecting centres where it was coagulated. The latex of *Landolphia dawei* is easily coagulated, for it will clot spontaneously if kept for a day or two; when treated with acetic acid like *Hevea latex* it coagulates readily and may be made into sheet. The latex of other vines is more stable and is not coagulated by acids.

The process of tapping the vines for rubber is a simple one; special tapping knives are not needed and the vines are slashed with a heavy straight knife or cutlass; three or four cuts are made close together, then a space of three or four feet is left untapped and another series of cuts is made. The latex flows quickly and is caught in a cup or a broad leaf; after about ten minutes, when the flow has ceased, the latex is poured into a pot or can and is carried out of the forest for coagulation. Before coagulation it is strained through gauze or through a native loofa to remove pieces of bark.

Clitandra orientalis may be regarded as the second most important rubber vine in Uganda. It is very common on the islands in Lake Victoria and in the forests near the shores and, except when it is in flower or fruit, it is easily mistaken for a *Landolphia*. The latex does not coagulate with dilute acids and the usual methods of preparation have been either to spread it in a thin layer on boards, so that it may dry into thin sheets, or else to boil it. In some cases the latex will coagulate readily, but in others prolonged boiling may be needed and a little salt may be added to accelerate the process. As in the case of *Funtumia*, the rubber is of good quality, although very dark in colour when coagulated slowly; this dark colour seems to be due to a process of oxidation of some constituents of the latex for, when the rubber is clotted quickly by the addition of alcohol, it is light in colour.

Clitandra rubber is tough, especially when it is cold; therefore it must be rolled out as soon as it has coagulated and while it is still hot. Furthermore, it must be prepared in small quantities; if a hand roller is available, up to two pints of latex may be boiled at a time and rolled out into a sheet; but if the latex is treated by peasants, who can only press out the rubber with a rolling-pin or a bottle on a board, each batch should not be more than about half a pint or the lump of rubber will be too thick to dry properly. There is also less risk that the rubber will be burnt if latex is boiled in small lots. Peasants are told to dry all the rubber they prepare by hanging up the sheets in the shade, as exposure to the heat of the sun makes it tacky; the soft rubber from *Landolphia dawei* is even more likely to be spoilt in this way than is the harder rubber of *Clitandra orientalis*.

Other species of *Landolphia* which occur in association with *L. Dawei* and *Clitandra orientalis* in some forests of the Masaka district are *L. ugandensis*, which appears to grow more on edges of the forests than inside them, and *Landolphia owariensis* (syn. *L. subturbinata*). Dawe stated of this latter vine, "it affords a pasty gutta-like substance, with little or no elasticity, and is of no value", but the old tappers declare that the vine was exploited, and specimens of rubber recently prepared from it seem to be of good quality. *Landolphia owariensis* is also common on the islands in the north of Lake Victoria—the Sese group, Kome and Buvuma—and on the edge of forests on the shores of the lake. It is interesting to note that all the best rubber-producing vines of Uganda—*Clitandra orientalis, Landolphia dawei, L. owariensis* and *L. ugandensis*—are especially abundant in and around secondary forests growing under heavy rainfall and on poor, acid, leached soils. These conditions are to be found on the shores of Lake Victoria; in other places at a distance from the lake, where the soils are better, these vines are relatively uncommon.

Another species of *Landolphia, L. florida,* is far more abundant throughout Uganda than any of the species mentioned above; it is found on forest edges in most parts of the country and is tolerant of a wide range of soils and climates. Unfortunately, this species is of little use for rubber production and, even when there was so high a price for rubber at the beginning of the century, it was not exploited in Uganda. It has been stated that "the latex is abundant and coagulates on prolonged boiling, but the product is resinous and worthless. It can be used as birdlime." (Dalziel, 1937). As the vine is so abundant in Uganda, the possibility that it might be tapped has been investigated; samples of latex (50 cc. in volume) collected from individual vines under close supervision have been coagulated by the addition of 40 cc. of rectified spirit. The coagulum has shown considerable differences, even when it was derived from vines growing close together: some samples have been quite hard, some soft and pasty, while one or two have been elastic. The average content of caoutchouc has been so small that it has not seemed worth while to exploit this species, but to concentrate on those which yield better rubber.

The same variation in the composition of latex has been found in the case of other species; as mentioned above, some vines of *L. owariensis* yield good rubber, although Dawe reported that the produce was worthless. It is very difficult to ensure that the latex is obtained from only one species of vine, for the lianes form a tangled mass of bare stems near the floor of the forest and the tappers identify them largely by the appearance of the bark and the slash. It is difficult to trace any individual stem up to the forest canopy, where the leaves are produced; flowers and fruit, which are necessary for authoritative determination of the species, are available only at some seasons of the year. (There is the same difficulty in obtaining pure *Funtumia elastica* latex; it is impossible to supervise closely hundreds of men scattered in the forest, and they may dilute the latex with that of other trees such as *Ficus* spp. and *Chrysophyllum* spp.: one new tapper left the forest and proceeded to cut herring-bones on the Para rubber trees of a neighbouring estate.)

Uganda is a prosperous country and the peasants can earn good incomes by the cultivation of crops such as cotton, coffee, tobacco, and various foodstuffs which are now urgently needed. It has been difficult therefore to obtain the labour needed for rubber production, especially for the exploitation of wild rubber. However, even the vine rubbers are now being exploited; the Crown forests in the Masaka district are being worked under licence from the Forest Department, and the forests on the islands, which are made up of small blocks in private ownership, are being exploited by the inhabitants. Organized collection on a large scale with paid labour would not be feasible in the Sese Islands on account of the weather; these islands are the wettest part of Uganda and it frequently rains there for all the morning and for half of the afternoon.

Uncontrolled exploitation of these vines by Africans was forbidden at the beginning of the century, as it was desired to husband Uganda's resources of wild rubber. There is no need to pay attention to such considerations at the present time; the heavy production to be obtained from selected clones and seedling families of Para rubber in the East, together with the huge synthetic rubber industry of America, renders it unlikely that wild rubber will be of any importance after the war, for rubber prices will be low—perhaps so low that it will not be profitable to tap even the Para rubber remaining in Uganda.

Sir Harry Johnston's prediction that rubber would be of great importance to Uganda has proved to be false; the wild rubber to which he referred was soon superseded by the produce of Para rubber estates. The plantation rubber industry of Uganda has had a sad career; it started with good prospects and high hopes, but it was soon evident that it would not be profitable and that the local conditions were better suited to other crops, such as Robusta coffee, sugar and tea. However, the estates carried on, going into production whenever prices permitted, contributing less than one-thousandth part of the world's output of rubber in the years before the war. Now, even that small amount—and it has been increased—is of great value; now this small industry is of some importance and can play its part in the war effort, even though it may be doomed to virtual extinction in a few years, and the rubber trees may be removed to make place for more profitable crops.

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GOATS AS A SOURCE OF MILK IN TSETSE AREAS

By H. J. Lowe, Director of Veterinary Services, Tanganyika Territory

As a general rule the keeping of goats in Tanganyika does not appeal to the European, possibly because he is not accustomed to handling these animals and also because he associates the goat with a characteristic repulsive smell. Whatever the reason, goat-keeping is almost entirely in the hands of Africans and Asiatics. The latter people have imported milk goats from India, though not in large numbers, and they have crossed these with our local types to produce an animal which with reasonable care and management is capable of giving enough milk to feed its offspring and a small surplus to supply the requirements of its owner, at any rate in part. Such goats can be seen in or around several of the larger townships of the Territory.

In this article, however, I am chiefly concerned with goat-keeping as a source of milk and meat supply in those parts of the country where, owing to the presence of tsetse fly, the keeping of cattle is at present out of the question. As examples of such areas I would point to Tunduru, Liwale, Utete, Pangani, Kilosa and some Sleeping Sickness Concentrations.

The native goat in this Territory is a small, compact, agile animal of almost any colour or mixture of colours and it will flourish in an area where sheep would not exist for long. They tend to multiply rapidly, as twins are frequently produced and where food is good usually kid down three times in two years. Their browsing habits render them much less prone to worm infestation than is the case with animals which graze. They have been blamed the world over as the main cause of soil erosion but as Hornby [1] and Staples [2] point out this slur on their character may be undeserved. The native nanny, however, is not on the average a good milker; in fact she is poor in this respect, but in many cases where the goat has a well developed udder, she may have the milk and refuse to "let it down". It is probable that with perseverance the goat could be persuaded to yield her milk provided the kid is present at the time, but our experience at Mpwapwa indicates that trying to milk the ordinary native nanny gives poor results and we therefore have been endeavouring to cross one or other of the milk types with the local strain. With the cross-bred nanny we have had no difficulty whatsoever in the milking. At first we tried the South African Boer goat but this was not satisfactory as a milk producer, so we then used the Toggenburg and later we switched to the British Alpine; but this breed in our experience is too delicate for our environment and we propose to return to the Toggenburg or the Indian as soon as conditions permit us to import fresh blood of these breeds.

We have found that, as with other domestic animals, the pure-bred of high-grade European breeds are not suited to our hot Tanganyika climate, but the half-grade and even three-quarters goats are proving themselves to be very useful types for milk production. We cannot recommend a higher grade than the three-quarter.

The milk yields which we get in the half-grade vary from 1.6 lb. to 3.7 lb. *per diem* with an average of 550 lb. (approximately 55 gallons) over 212 days in lactation. The highest individual lactation record is 95 gallons, which is more milk than the average native cow in the territory produces in one year under normal local conditions.

These figures represent total yields and would of course be appreciably reduced if allowance is made for the requirements of the kids, but when milk production is the main concern one or both of the kids may be destroyed at birth.

Goat's milk in our tests averaged approximately 5.6 per cent butter-fat and 9.6 per cent solids-not-fat, so that as far as food value is concerned it is the equal of cow's milk. It can also be used for butter- or cheese-making.

Management of Goats

(*a*) *Feeding.*—As a rule goats run under the average native conditions only get the food that they can pick up for themselves, but every goat which yields ten ounces or over daily should be given a production ration and it is suggested that in cases where the animals are likely to get reasonable attention, such as at mission stations or Native Authority farms, supplements might be fed with advantage to the better milkers. Goats readily eat cotton-seed, groundnut cake and crushed maize or sorghums. All of these are usually obtainable. The ration as fed at Mpwapwa is made up as follows:—

Cotton-seed	50 lb.
Groundnut Cake	33 lb.
Crushed Maize	33 lb.
Mineral Mixture	3 lb.

The mineral mixture is lime 1, salt ½, bone meal ½ by weight.

The above ration is fed to all milkers at milking time at the rate of ½ lb. maintenance and ¼ lb. per pound of milk produced. The herd billy is also fed 1 lb. of this ration daily during the dry season.

(*b*) *Watering.*—Goats should be watered twice daily, morning and evening.

Toggenburg billy with two half-bred Toggenburg-native yearlings

Some of the Mpwapwa flock of grade milch goats

(*c*) *Herding.*—The flock should always be divided into two herds, i.e. the herd of goats in milk and the herd of dry goats and youngsters. On no account should the billy goat be allowed to run with the milking goats. He should either be kept indoors and hand-fed or run with the dry goats and youngsters. He should never be allowed into the milking shed or near the milking goats, otherwise the milk will almost certainly be tainted. This may not matter a great deal where the African is concerned but Europeans are likely to find the "bouquet" rather strong for their palates.

Goats are difficult animals to herd. They cover the ground faster than most other herbivora and in thicket or woodland country they are very prone to stray and so become easy victims for leopard, lion, hyena, jackal and wild dog.

Where only a few high-yielding goats are kept it may be preferable to tether them, but in such cases the tether rope should not be long and the peg should of course be moved daily. Goats do not do well if kept indoors.

(*d*) *Housing.*—This should be thoroughly clean and secure against the depredations of vermin. It should be as open as possible but sheltered from rain and well ventilated, otherwise pneumonic trouble will ensue.

The milking goats should always be housed well away from the billy (who will be kept with the dry herd) and they should be groomed each day. A little attention to the sanitation of the buildings and the cleanliness of the animals themselves will be well repaid. Here again the native may not be able to do a lot but this is the goal to be aimed at, particularly if importance is attached to the milk produced being free from taint.

Diseases of Goats

Goats as a rule are the hardiest of animals but they are subject to certain diseases in this country; the chief of these are:—

(*a*) *Infectious Pleuro-pneumonia,* which sweeps through the country from time to time and kills off anything up to 100 per cent. There is as yet no protective inoculation against this disease in this country, but recent research in India gives promise of a successful measure of control. The only thing to be done at present is to keep the animals segregated as far as possible when the disease is known to be in the neighbourhood.

(*b*) *Heartwater.*—This is a tick-borne disease carried as a rule by the *Amblyomma* species. Treatment by "Uleron" has proved effective but generally death is rapid.

(*c*) *Anthrax.*—This is as a rule a "sudden death". The disease is communicable to humans so care should be taken in all cases of sudden death to bury the carcass intact. Annual vaccination will give a satisfactory protection.

(*d*) *Mange.*—This can spread rapidly through a flock and if left untreated it can cause quite a heavy mortality. A dressing consisting of flowers of sulphur 4 lb. parts, oil of tar 1 litre, used engine oil 4 gallons should be applied.

(*e*) *Plant poisoning* is not infrequent.

(*f*) *Brucellosis.*—This infection is known to occur in Tanganyika and as human beings are susceptible to it, the milk should be boiled. The same remarks apply to cow's milk.

(*g*) *Worms.*—These cause less trouble in goats than in sheep but sometimes they do suffer severely and in these instances the treatment is the same as for sheep, i.e. regular dosing with anthelminthics.

(*h*) *Trypanosomiasis.*—As the object in view in this article is to encourage the production of milk in tsetse-infested areas the question will be asked: "Will the goats suffer from trypanosomiasis?" I would reply by stating that although goats cannot be kept in tsetse areas with impunity, nevertheless they are capable of surviving for much longer periods than cattle and in lightly infested fly country they may carry on almost indefinitely. This fact has given rise to a popular opinion that goats are immune to tsetse fly disease but although I can find no concrete scientific proof to support this view as yet, nevertheless there are some grounds for believing that goats may have a greater resistance to trypanosome infection than other domesticated animals. It is pertinent too that in certain of our Sleeping Sickness Concentrations goats have not only survived but so far have even increased and flourished whereas cattle herds in the same areas have been completely wiped out. These remarks are made in connexion with the native goat in Tanganyika Territory and whether or not they apply to grade animals remains to be seen. It is hoped to carry out some investigations on this subject when circumstances allow. Goats, however, do suffer from trypanosomiasis and may succumb to it if they are not treated. The degree of infection in a flock will depend largely on the density of the "fly".

The treatment of infected cases can be carried out quite simply. The usual method recommended by us is the subcutaneous injections of "Stibophen", but blood slides should be sent to the nearest veterinary office or to the Veterinary Laboratory, Mpwapwa, for examination and advice.

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THE FEEDING VALUES OF GREEN LUCERNE AND LUCERNE HAY

By M. H. French, M.A., Ph.D., Veterinary Laboratory, Mwapwa, Tanganyika Territory

Seasonal droughts cause the natural grazings to dry off and become of low feeding value so that difficulties are then experienced in maintaining the productivity of high-grade stock (e.g. dairy cows). Progressive farmers attempt to minimize the effects of the dry season by growing green crops under irrigation and lucerne is usually one of the fodders cultivated. The object of this article is to record the results of an investigation into the feeding values of green lucerne (*a*) when grown during the rainy season when growth is vigorous, (*b*) when grown under irrigation during the height of the dry season when growth is less vigorous, and (*c*) when the crop is cut just as the plants commence flowering instead of just after flowering has started. In addition, the feeding value of lucerne hay, made from plants grown during the wet season, was also determined because there is ample green food available during the rains and lucerne grown at that time will be of greater value if converted into a reserve fodder for use in the dry season.

Apart from determining the feeding values of lucerne, this work was undertaken (1) to find out whether lucerne grown under irrigation had the same feeding value as when grown under normal rainfall conditions and (2) to see if the cultivation of this crop were justified under Tanganyikan conditions. In England, Woodman *et alii* found that lucerne, as a source of digestible protein and starch equivalent, was inferior to young pasture grass up to five weeks old. In recent years I have advocated the growing of lucerne, in suitable localities, both in private talks and in lectures to farmers, so that, if the results of the Cambridge workers applied to our local conditions, a serious revision of this advice would be necessary.

The crop used for these studies had been planted eighteen months previous to the first trial, which was made on green lucerne grown under irrigation in the dry season. The second trial was made six months later when the plants had grown in the wet season. In both these trials the crop was cut at the flowering stage but, since Woodman *et alii* have shown that the chemical composition of lucerne changes considerably with advancing maturity, a third trial was made on lucerne grown in the wet season when the plants were in bud. The hay was not wetted nor handled more than was necessary and was chaffed to get greater uniformity in the feeding trials. The compositions of these samples are given in Table I and it may be of interest to record that dry-season lucerne had a slightly higher dry-matter content (30 per cent) than the wet-season crop (25 per cent).

The organic compositions agree fairly well with other published figures for lucerne and indicate that, when grown under irrigation in the dry season, the crop was less fibrous. This is probably correlated with the less vigorous growth and the thinner stems.

TABLE I

COMPOSITIONS OF GREEN LUCERNE AND LUCERNE HAY (Dry-matter Basis)

Type of Crop	Green Lucerne			Lucerne Hay
Season of Growth	Wet season	Dry season	Wet season	Wet season
Stage of Maturity	Early flowering	Early flowering	Budding	Flowering
Heights of Plants	20–24 in.	12–18 in.	18–22 in.	30 in.
Crude Protein	18·46	19·39	20·56	16·47
Ether Extract	2·27	2·72	2·45	2·03
N-free Extract	44·96	48·08	42·30	38·13
Crude Fibre	25·48	20·99	24·89	31·38
Total Ash	8·83	8·82	9·80	11·99
SiO_2	0·08	0·51	0·58	1·10
SiO_2-free Ash	8·75	8·31	9·22	10·89
CaO	2·988	2·999	3·080	2·811
P_2O_5	0·496	0·518	0·504	0·694
K_2O	2·019	1·984	2·501	2·546
Na_2O	0·465	0·482	0·465	0·375
Cl	0·496	0·376	0·361	0·545

All the samples are rich in mineral matter especially lime and potash. It is worth noting that the ash of lucerne is unbalanced in its proportions of lime and phosphate—the CaO/P_2O_5 ratio is much higher than that normally regarded as the optimum for stock feeds—but the crop is certainly not deficient in phosphates. The minerals of lucerne will best be utilized by feeding in combination with cereal concentrates which are rich in phosphate and will counter-balance the excess of lime in lucerne.

The analysis of lucerne hay shows that the slightly older crop and the losses of leaf during curing have resulted in lower protein but higher fibre contents. The content of soluble ash remains high.

The digestibility trials revealed that locally grown lucerne had digestibility co-efficients of the same order as lucerne grown in England but, as would be expected, the hay was less digestible than the green crop.

Woodman *et alii* found that the crude fibre content of flowering lucerne was greater than that in one to five weeks old pasture grass and corresponded with the amount in grass at the hay-making stage of maturity. They also observed that "lucerne, both in bud and flower, is distinctly inferior in digestibility and nutritive value to pasture herbage submitted to systems of cutting at intervals from one to five weeks. This difference is particularly marked in the case of the fibre, which in pasture herbage is non-lignified and of high digestibility, but in lucerne is woody and of low digestibility".

Data on the compositions, digestibility and nutritive values of some Tanganyika grasses have been published elsewhere [3] from which it will be seen that, in this Territory, green grass is considerably richer in fibre than British grasses and that consequently green flowering lucerne contains less fibre than most local grasses. Further, the protein of lucerne is digested better than that of local grasses in general, though the protein in short grass of the better local species is digested as efficiently as that in lucerne. The lucerne fibre is, however, digested much less efficiently than the fibre of local grasses and, because of the poor digestibility of its lignified fibre, the general level of lucerne digestibility, as represented by the values for its organic matter, is usually below that for young local grasses. Similarly, lucerne hay shows a higher value for the digestibility of protein but a lower co-efficient for its fibrous constituents than found for local hays.

The digestible nutrients and starch equivalent values for the various lucerne samples are shown in Table II together with the figures of the Cambridge workers for lucerne grown in England.

These figures indicate that the Mpwapwa samples of lucerne have similar feeding values to lucerne grown in England. It is also seen that lucerne grown under irrigation in the dry season has, for all practical purposes, the same feeding value as lucerne grown during the wet season without irrigation.

The growing of lucerne has been advocated on the basis of its reputation as a source of the digestible protein so badly needed by high-producing animals in the dry season. In England it has been shown that its reputation for this purpose has been exaggerated for English conditions where pasture herbage has been proved an excellent source of protein. In Tanganyika the grasses are not so rich in protein and their content of digestible protein is less than that in flowering lucerne. The starch

TABLE II

Digestible Nutrients and Starch Equivalent Values for Green Lucerne and Lucerne Hay
(Per 100 parts dry matter)

Nature of Crop	Hay	Green Lucerne				
Season of Growth	Wet season	Wet season	Dry season	Wet season	England	
Stage of Maturity	Flowering	Early flowering	Early flowering	Bud	Flowering	Bud
Digestible Crude Protein ..	10·74	13·54	14·29	16·52	12·96–15·33	15·49–17·97
,, Ether Extract ..	0·32	0·16	0·83	0·34	0·20– 0·47	0·12– 0·66
,, N-free Extract ..	24·77	32·13	34·22	33·68	27·54–29·50	28·42–31·33
,, Crude Fibre ..	13·74	12·67	5·29	13·19	10·70–13·37	11·08–13·89
,, Organic Matter ..	49·42	58·50	54·63	63·73	53·44–58·29	58·44–61·61
Starch Equivalent	30·72	43·06	42·36	48·61	42·44–47·28	48·66–57·51
Nutritive Ratio	1:3·6	1:2·9	1:3·3	1:2·9	2·83– 3·20	2·34– 2·84

equivalent value of flowering lucerne is of the same order as, or slightly lower than, that of local grasses up to twelve inches in height.

It appears, therefore, that the growing of lucerne in this Territory for dry-season feeding is justified because, when cut at the early flowering stage of maturity, it possesses the same energy value as young grass and is superior in this respect to the dried-up grazings available in the dry season. In addition green lucerne contains more than double the amount of digestible protein found in the dry pastures and fodders available in the dry season.

The making of lucerne hay in the wet season for feeding during the dry season is also justified because it contains twice as much digestible protein and the same amount of energy value as is found in one of the best local hays (from *Cynodon plectostachyum*. Hays made from other local leguminous crops (such as cowpeas, velvet beans and groundnut tops) have slightly higher energy values but less digestible protein than lucerne hay.

Summary

(1) Green lucerne grown under irrigation in the dry season has the same nutritive value as that grown in the wet season, and the feeding values of Mpwapwa samples are similar to those reported from England.

(2) Green lucerne cut just before flowering has a higher feeding value than if cut after the plants have started to bloom.

(3) Green lucerne has not only more energy value but also more than double the digestible protein content of the local dry-season grazings. It can be recommended as a crop for growing under irrigation in the dry season.

(4) Lucerne grown in the wet season should be made into hay for use during the dry season.

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POST-WAR PRODUCTION OF FOOD

The pre-war policy of dealing with gluts has to be changed. There is a great world shortage of food. There is no likelihood of a world glut of things in our day or in our children's day: and the stupid political policy which, not through evil thoughts but through ignorance on the part of economists, financiers, and politicians, was restricting the production of food and the distribution of food in times of so-called glut, would need to be replaced by measures in which science would be applied with all its power to improve the production of food. Trade will be facilitated for the adjustment of the distribution of food in accordance with the needs of the people.

If we are going to attain that in the world after the war, we will need to take an estimate of the food which each country can produce; and the kind of food which will be grown and which each country can most easily cultivate. If two acres of land can produce more sugar in the West Indies than two acres of land can produce in this country, the West Indies will need to give itself up to the production of sugar, because we need our land to produce milk and other things as profitably as other countries can do. In other words, there will need to be an interchange of food between nations. We will need not only to produce more food in this country but we will need to import more food. The interchange of food between nations will lead to the interchange of other commodities; and so you will have to lay a basis for expanding trade.

There is another very important thing from the economic point of view, and that is that the amount of food which we need to produce from any group of countries in the whole world can be fairly accurately estimated. If we produce somewhere more than is needed, the people cannot eat it. If we produce less, we will know that there is a shortage there. So that you can arrange your food policy on a stable basis. If there is a trade boom or a trade slump, people will need the same kind of food, and they must produce the food required for human needs. As the consumption of food represents a great proportion of the annual income of almost every country of the world, if you introduce that kind of policy you introduce a stabilizing factor in the whole trade of the world.

Sir John Orr, D.S.O., F.R.S., at the meeting of the British Association, September, 1941.

NOTES ON ANIMAL DISEASES
XVIII—LUNG DISEASES AND PYAEMIC INFECTIONS OF SHEEP

Compiled by the Veterinary Department, Kabete, Kenya

In parts of Kenya lung diseases are one of the most important causes of sheep mortality, particularly in grade Merino flocks. From the etiological view-point we can recognize no fewer than six types of pneumonia; but clinically, if we omit the pneumonic form of sheep-pox, they fall into two clearly defined groups, acute suppurative pleuro-pneumonia of lambs and the chronic pneumonias of older sheep. The former group includes only one disease, which not uncommonly occurs in epizootic form. The latter includes caseous lymphadenitis, abscesses due to the infection of old worm nodules by various pyogenic organisms, lung-worm infestations and the condition usually known by the South African name "jaagsiekte."

During an outbreak of sheep-pox cases of acute pneumonia may be caused by the virus, but there is no reason to discuss these cases further. Secondary infection of sheep-pox lesions may also produce a chronic infection of the lungs similar to the infection of old worm lesions.

In general, the chronic types of pneumonia are more common in old ewes and rams, and one would expect isolated cases in a flock throughout the year. In actual fact, however, one frequently sees what appears to be an outbreak occasioned by shearing; heavy rain or other sudden changes in weather; movement or other extrinsic factors. Such outbreaks are due to the "lighting up" of a hitherto quiescent infection in the lung.

Since the lungs are the most frequent site of pyaemic lesions in sheep it is convenient to describe pyaemic and lung diseases together.

Suppurative Pleuro-pneumonia and Pyaemic Conditions of Lambs

Suppurative pleuro-pneumonia is a clearly-defined clinical entity affecting lambs up to the age of four months. The etiology is not fully understood; but there is no doubt that the condition is to some extent a pyaemic disease, that is to say, that the bacteria which are responsible for the lesions in the lungs are brought there by the blood. In the majority of outbreaks of this disease, a large proportion of the lambs that die show lesions in organs other than the lungs and the disease then corresponds with pyaemia of lambs as seen in other countries. Occasionally, however, in a severe form affecting lambs from 3-6 weeks of age, almost every lamb that dies shows lung lesions and it would appear that a second factor operates in such outbreaks and causes the organisms in the blood to become localized in the lungs. The actual organisms found in the lesions vary in different outbreaks and are rarely present in pure culture. In a particular outbreak one, small Gram-negative bacillus will usually occur constantly, but will be associated in different lambs with *C. pyogenes* or with various Gram-positive cocci. In a second outbreak a similar but apparently not identical Gram-negative bacillus will be present. It is unlikely, therefore, that the bacteria that have been isolated are the sole cause of the disease.

The epizootic lung disease of young lambs is most prevalent in dry weather, a fact which suggests that irritation due to dust or decreased resistance due to some nutritional factor being lacking, may play a part in the etiology.

Symptoms.—In typical, acute lung cases the animal dies very shortly after it has been noticed to be sick, often being found dead in the "boma" in the morning. When observed, symptoms consist of dullness, lack of appetite, thirst and a foul-smelling discharge from the nostrils. The temperature may be as high as 107°, and if driven the lambs soon become distressed and some of them will cough.

In most outbreaks, however, there are cases of infection in parts of the body other than the lungs. When the joints become infected we have joint-ill: the joints swell and the lambs are lame. The joints affected in decreasing order of frequency are the stifle, knee, hock, shoulder, elbow and hip. Lambs with lesions in the brain or liver usually show no symptoms; but nervous symptoms are shown occasionally.

Lesions.—The essential lesions are abscesses, which if present in soft organs, such as the lungs or liver, may vary in size from a pea to an orange. Several are commonly present and their contents are usually pale yellow or blood-stained. Abscesses in the lung are surrounded by solidified pneumonic areas, greyish or red in colour and often showing multiple pin-head-sized, yellowish spots. The chest cavity usually contains a stinking puru-

lent fluid and in such cases affected parts of the lung and the adjacent lining of the ribs are covered with a felted or web-like, yellowish deposit.

If lesions are present in the liver they consist of abscesses of varying size. Swollen joints show on section, purulent material in the joint cavities. In cases where no obvious lesions are present in the soft organs or joints, the brain should always be removed, for localization of infection on the floor of the brain-box is fairly common. In such cases a focus of pus, frequently at the anterior end between the meninges, will be found.

Treatment.—No curative treatment of value has been elaborated. Prophylactic vaccination has in some cases given promising results; but, for preference, vaccine should be made from organisms isolated from cases in the same outbreak.

Some outbreaks are undoubtedly due to infection of the navel at birth or of the tail stump at docking or of the purse at the time of castration. Every effort should be made to prevent such infections by tying and dressing the stump of the cord at birth and by attention to cleanliness and dressing with antiseptics when operating.

Caseous Lymphadenitis

Caseous lymphadenitis is a chronic disease of sheep and goats caused by *Corynebacterium pseudotuberculosis-ovis*. This organism is closely related to that responsible for ulcerative lymphangitis in horses, in fact the older authorities considered the two organisms as identical. By modern technique, however, the two organisms can be distinguished quite easily.

The organism gains entrance to the body through small skin wounds and may cause a local lesion. More frequently, however, it passes to the regional lymphatic gland where it multiplies and produces a cold abscess. Many cases of the disease are never detected during life; in fact the disease first came into prominence when the lesions were found in England in mutton shipped from Australia. The abscesses develop very slowly and on section are found to contain a pale yellow or slightly greenish-yellow pus usually of a cheesy consistency. The character of the pus has led to the use of the name "ovine pseudotuberculosis" for the disease. Frequently the pus appears to be in layers resembling in structure an onion.

At times the organism of caseous lymphadenitis causes abscesses in the lungs. It is probable that in these organs the bacillus begins to multiply in an old parasitic lesion for it is doubtful if the bacillus is ever the primary cause of a lesion in the normal lung tissue. The abscesses in the lung resemble those found in glands. Sheep with large areas of lung involved may die suddenly after heavy rain or after shearing and dipping.

There is at present no treatment either curative or preventive for caseous lymphadentis. Although fairly common in old sheep, the disease cannot be said to be of very great economic significance in Kenya at the moment.

Pyogenic Infection of Old Worm Lesions

As distinct from true lung-worms various platyhelminths migrate on occasion to the lungs. Rarely liver fluke pass to the lungs instead of the liver and they cause damage to the lung tissue during their migrations. Eventually they die and for a time a focus of dead organic matter is thus left in the lung. The defence mechanism of the body is normally capable of absorbing this foreign material in time; but before this happens the material may become infected with a pyogenic organism, and particularly when the animal is in a poor state of health, an abscess then results. Much more frequently the intermediate stage of the dog tapeworm, *Echinococcus granulosus*, passes to the lung and what is known as a "hydatid cyst" develops. This consists of a membranous sac, sometimes divided into pockets, containing watery fluid and a large number of very small bodies each of which, if swallowed by a dog, is capable of developing into a small tapeworm. After several months a hydatid cyst begins to degenerate and, as a result, a focus of dead foreign matter capable of becoming infected and developing into an abscess is left. Abscesses originating in this way are fairly common in old ewes and rams and following shearing and dipping they may give rise to a septic pneumonia.

It is obvious that the type of organism present in abscesses of this nature is largely a matter of chance and preventive inoculation is unlikely, therefore, to prove effective. With the idea of reducing the incidence of *Echinococcus* cysts in sheep and cattle, regulations have been introduced in New Zealand to the effect that every dog shall be treated twice a year with arecoline hydrobromide to expel

the adult worms. In Kenya it has been observed that abscesses in the lungs of adult sheep are more common on farms where the herds are allowed to keep dogs, and it is suggested that owners of sheep should allow only a minimum of dogs and should insist on the dogs being regularly wormed.

Lung-worms of Sheep

There are three species of roundworm commonly found in the lungs of sheep in most parts of the world. *Dictyocaulus filaria*, the thread lung-worm, lives in the medium-sized and larger bronchi and causes verminous bronchitis or "husk" or "hoose" as it is more commonly named. The others, *Synthetocaulus rufescens* and *Muellerius capillaris* (the hair lung-worm) live in the smaller bronchi and air cavities, and are responsible for verminous broncho-pneumonia. In addition *Muellerius capillaris* frequently invades the connective tissue of the lung where it produces small nodules.

Severe outbreaks of these parasitic infestations such as occur in flocks of weaners in England, have not been recorded in Kenya but in most large Merino flocks the two last-mentioned parasites are responsible for a considerable annual wastage of older sheep. Sheep that are pulled down in condition are more likely to succumb to the effects of the parasites than healthy sheep, and death is not infrequently due to a secondary, septic pneumonia.

Symptoms.—In hoose the cough is a fairly typical indication of infection. The respirations are quickened and the sheep are easily exhausted when driven. Condition is lost and the skin becomes dry and harsh. The wool is easily pulled out and there is a certain degree of anaemia.

In the conditions caused by *S. rufescens* and *M. capillaris* the symptoms are generally similar but coughing is less marked and the disease develops much more slowly. Diagnosis during life is more difficult. Infection with more than one species is common.

Lesions.—The lesions produced in pure infestations of the two types of condition are fairly characteristic, at least in the early stages.

In *Dictyocaulus* bronchitis the lesions are due to obstruction of the larger air channels by felted masses of worms, and the excessive mucous secretion which their presence excites. In the early cases the lesions are usually restricted to the very posterior tip of one or both lungs which turns dark red or grey, and has a solid feel. Infection spreads anteriorly and, since the larger channels are affected, large, sharply demarcated areas become involved in turn. The surface of the affected portions of lung may be covered with a thickened, whitish membrane.

The larvae of the other two forms of worms pass into the smallest air cavities of the lung where, as they grow, they break through the thin walls. This mechanical damage, combined with irritation caused by their secretions, leads to a local reaction. Hence, instead of the lesion being concentrated in one fairly extensive area as in the case of *Dictyocaulus*, many small nodules are formed. Soon after infection the surface of an infected lung shows nodules projecting slightly above the surface and a few millimetres in diameter. The nodules have a soft greenish centre and are surrounded by a thickened wall. Later in the case of *S. rufescens* the adult parasites migrate to the bronchi, mate, and eggs are produced by the females. The eggs and larvae are found around the female worm in the air cavities, where they produce a diffuse pneumonia. A nodule, solid to the feel and reddish or grey in colour, is found. Frequently several nodules coalesce to produce a larger, irregular pneumonic area. If the parasites are overcome by the resistance of the sheep the contents of the nodules may be cheesy or calcified and enclosed in a capsule.

In *Muellerius capillaris* pneumonia the adults are found in capsules in the connective tissue of the lung. On the surface of the lung these capsules appear as semi-transparent white nodules about the size of lentils. The larvae are found in the consolidated reddish or greyish, lower portions, usually of the posterior lobes.

Life History.—Eggs laid by females in the lungs develop into larvae which are passed out onto the grazing. In the case of *Muellerius* the larvae develop further in slugs before reaching the infective stage for sheep. *Dictyocaulus* larvae have no intermediate host and the complete life cycle of *Synthetocaulus* has not yet been revealed. With all the species infective larvae are eaten with the food and migrate via the lymph channels to the lungs. Larvae on grazing are very long-lived under moist conditions but are less resistant to hot, dry spells.

Treatment.—The intratracheal injection of various drugs is claimed to be efficacious in the treatment of *Dictyocaulus* infection but medicinal treatment is of no value for the

other species. In all types, the majority of cases, if taken in time, respond remarkably to good feeding.

Chronic Proliferative Pneumonia

The etiology of this disease, which is also known as epizootic adenomatosis and, in South Africa, as "jaagsiekte," is unknown. A certain amount of proliferative pneumonia is caused by lung-worms of the genus *Muellerius;* but lesions of jaagsiekte are microscopically distinct. An extensive investigation of what would appear to be the latter condition has been made recently in Iceland and the results suggest that the disease is infectious, and that it was introduced into the island with a Karakul ram imported from Germany in 1933. The disease in Kenya occurs mostly in old sheep and outbreaks of the type seen in Iceland are never encountered. It must be remembered, however, that housing of sheep during the Icelandic winter greatly facilitates the spread of an infectious disease, the causal agent of which is presumably dispersed by coughing.

Symptoms.—The first symptom to be noticed is a cough, at first slight, later rather persistent. Respirations become quickened and if driven the sheep soon becomes "out of breath." After a time a watery discharge develops from the nose and in the advanced stages a frothy mucous fluid may run from the nostrils when the sheep puts its head down. The average duration of the disease is from two to three months. Until the final stages the appetite is not affected and there is little loss in condition. The temperature usually runs a normal course; but if, shortly before death, a secondary bacterial infection of the lung occurs, the temperature may become elevated.

Lesions.—When the sheep is killed before secondary infection occurs, the lungs are found enlarged, with areas of an abnormal greyish tint. These areas may be as small as a bean or the greater part of a lobe may be affected. In advanced cases the lower edges of the lungs are most frequently involved. In early cases a number of areas are usually present, the larger areas found during the later stages being caused by the coalescence of several small ones. The affected tissue does not project from the normal lung surface, and on section the building up of large areas from small ones is usually easy to detect.

Affected tissue differs from typical pneumonic lung in being more friable. Whilst difficult to describe the lesion is easy to recognize once it has been seen. There are no characteristic lesions in other organs.

Microscopically sections of the lesions show the development of a type of tissue seen in the malignant new growth called an adenoma.

Control.—No method of inoculation has been developed.

The administrators of a new country and all who have to decide problems of the most scientific, and therefore the best and most economical utilization of land, should be ecologically minded and should realize that vegetation is essentially dynamic, always progressing towards some position of equilibrium (climax) under the influence of the different factor-complexes to which it is subjected. They should have a firm grasp of the principles of succession and should recognize it is only by careful study of particular cases in the light of these principles that valid and useful decisions on the fate of different areas can be reached.

Prof. A. G. Tansley in *Farm & Forest.*

Modern agriculture follows the enlightened dictum of the man from the Middle West who said, "Posterity never did nothing for me".

Dr. F. Fraser Darling in *Island Days.*

[This aspersion on modern agriculture was, we believe, more generally true ten years ago than it is to-day.—*Ed.*]

NUTRITIONAL RESEARCH

When it comes to applying in practice what has been learnt in laboratory, in field and in hospital ward, and applying it to the largest possible number of people over the largest possible areas of the world, others with expert knowledge are needed to add their counsel to that of the scientific investigator and the practising physician. The anthropologist, the educationist, the sociologist, the geneticist, the economist, among many, are able to contribute data of value to those who wish to direct the maximum quantity of the best foods to the places where the people most need it, and to secure that the people who most need it are persuaded to eat it, and can afford to do so—to eat it, moreover, before any appreciable proportion of its essential nutrients has been lost.

Nature.

WRITE SIMPLY!

They said: "They would take immediate steps to embark upon an examination of the plans."

Try: "They would at once examine the plans."

HOST LIST OF THE PARASITIC FUNGI OF UGANDA

PART I

By C. G. Hansford, M.A., F.L.S., Senior Plant Pathologist,
Uganda Department of Agriculture

The host list published in this *Journal* in 1937-38 contained a considerable number of fungi of which the names have now been revised in the light of more recent research and comparison with similar fungi in other parts of the world, with the result that that list is now out of date. Collection has been continued during the interval and a considerable number of new records are included in the list given below. The new species listed as described by the author are included in a series of papers on the Fungus Flora of Uganda, as follows:—

1. Meliolineae of Uganda, by C. G. Hansford in *Journ. Linn. Soc.*, li, p. 265 *et seqq.*, 1937.
2. Meliolineae of Uganda, Supplement, by C. G. Hansford, *l.c.*, li, p. 537 *et seqq.*, 1938.
3. Some Uganda Ascomycetes, by C. G. Hansford in *Proc. Linn. Soc.*, cliii, p. 1 *et seqq.*, 1941.
4. Ustilagineae of Uganda, by G. C. Ainsworth, *l.c.*, cliii, p. 95 *et seqq.*, 1941.
5. Fungi Imperfecti of Uganda, by C. G. Hansford, in *Proc. Linn. Soc.* (in the press).
6. The genus *Eriomycopsis* Speg., by C. G. Hansford in *Bothalia*, iv, p. , 1942.
7. The Superficial Leaf Inhabiting Ascomycetes, by C. G. Hansford (in preparation for publication in *Journ. Acad. Sci.*, Washington).

At present the largest group of Uganda Fungi awaiting revision comprises the Rusts, of which a large number of collections have been made, and it is hoped that with the assistance of specialists in this group an authoritative list of these may be available in the near future. Apart from the fungi included below, there are records in Uganda of a considerable number of saprophytic fungi of all groups with the exception of Agaricaceae, to which little attention has so far been paid on account of the difficulty of preservation of specimens and of specialized knowledge of the tropical agarics. In all groups the writer has to acknowledge the valuable assistance rendered by specialists, notably the late Prof. F. L. Stevens, Prof. Charles Chupp, Dr. E. M. Doidge, Miss E. M. Wakefield, Mr. E. W. Mason, Dr. G. R. Bisby and Dr. G. C. Ainsworth.

ALGAE

CLOSTERIUM spp.
 Myzocytium proliferum Schenk.
OEDOGONIUM spp.
 Olpidium entophytum Braun.
SPIROGYRA spp.
 Lagenidium Rabenhorstii Zopf.
 Myzoxytium proliferum Schenk.
 Rhizophidium globosum (Baun) Schroter.
PLEUROCOCCUS sp.
 Nectria hæmatites Syd.

FUNGI

ASTERINACEAE
 Phaeodimeriella Asterinarum (Speg.) Theiss.
 Phaeodimeriella plumbea Doidge.
 Dimerium pulveraceum (Speg.) Theiss.
 Philonectria ugandensis Hansford.
 Calonectria arcuata Hansford.
 Loranthomyces ugandensis Hansford.
 Cephalosporiopsis parasitica Hansford.
 Eriomycopsis africana Hansford.
 Eriomycopsis angustispora Hansford.
 Eriomycopsis Asterinae Hansford.
 Eriomycopsis flagellata Hansford.
 Eriomycopsis Trichiliae Hansford.
 Titaea callispora Sacc.
 Titaea Ugandae Hansford.
 Verticiciladium ugandense Hansford.
 Cercospora Chandleri Hansford.
 Helminthosporium sp.
 Saccardomyces sp. ("*Leptosporella Asterinae* Hansf.").
CLADOSPORIUM sp.
 Cephalosporium sp.
 Fusidium sp.
ELSINOE spp.
 Oospora sp.
 Fusarium macroceras Reinking & Wollenw.
 Fusarium stilboides Wollenw.
 Cladosporium sp.
 Hyalodendron sp.
ENGLERULA MACARANGAE P. Henn.
 Mycolangloisia Englerulae Hansford.
 Eriomycopsis Trichiliae Hansford.
HELMINTHOSPORIUM TRIUMFETTAE P. Henn.
 Verticullium epiphytum Hansford.
 Sporotrichum Triumfettae Hansford.
HYPOXYLON spp.
 Ceratosphaeria lampadophora (B. & Br.) Niessl.
 Nectria Rickii Rehm.
 Nectria vilior Starb.
KRETZSCHMARIA sp.
 Sphinctrina cubensis B. & C.
MELIOLINEAE
 Chaetodimerina Bosquieae Hansford.
 Dimerina Meyeri-Hermanni (P. Henn.) Theiss.
 Dimerina longispora Hansford.
 Dimerina parasitica (Sacc.) Hansford.
 Phaeodimeriella parvula (Cooke) Hansford.
 Dimerium Langloisii (Ell. & Ev.) Theiss.
 Dimerium leptosporum (Speg.).
 (*Dimerium mindanaense* (P. Henn.) Hansford on *Meliola* on *Rhynchospora* Amani, Tanganyika. (=*Dimerosporium apertum* Syd.).
 Dimerium piceum (B. & C.) Theiss.
 Dimerium pulveraceum (Speg.) Theiss.
 Dimerium venturioides (Sacc.) Hansford.
 Phragmeriella Ireninae Hansford.
 Phaeophragmeriella Balladynae Hansford.
 Phaeophragmeriella Meliolae (Stev.) Hansford.
 Phaeophragmeriella caudicium (Syd.) Hansford.
 Phaeophragmeriella clavisporum (Syd.) Hansford.
 Phaeophragmeriella meliolicola (Syd.) Hansford.
 Saccardomyces Asterinae Hansford.
 Saccardomyces kigeziensis Hansford.
 Nectria byssiseda Rehm.
 Letendraea sp.
 Paranectria flagellata Hansford.
 Paranectria meliolicola Stevens.
 Paranectria meliolicola Stev., var. *major* Hansford.
 Paranectria minuta Hansford.
 Paranectria Ugandae Hansford.
 Paranectria Wildemanniana P. Henn.
 Paranectria spp., *Hansford 2379* and *Hansford 2878* each differ from any of the above.
 Calonectria Chorleyi Hansford.
 Calonectria guarapiensis Speg.
 Calonectria inconspicua Wint.
 Calonectria limpida Syd.
 Calonectria Meliolae Hansford.
 Calonectria Ugandae Hansford.
 Calonectria sp., *Hansford 2554*, etc., with conidial stage *Cephalosporium* sp.

In this contribution, regarded as to "pure", rather than applied mycology, the capitalization of specific and varietal names is retained at the author's request.

Melioliphila graminicola (Speg.) Speg.
(?)*Actinopeltella* sp., *Hansford 2632.*
Calloriopsis gelatinosa (Ell. & Mart.) Syd.
Sporotrichum Meliolae Hansford.
Cephalosporium sp.
Spicaria sp., *Hansford 1852.* ..
Acremonium Meliola Stevens.
Eriomycopsis angustispora Hansford.
Eriomycopsis Bomplandi Speg.
Eriomycopsis Bosquieae Hansford.
Eriomycopsis Chorleyi Hansford.
Eriomycopsis flagellata Hansford.
Eriomycopsis hamata Hansford.
Eriomycopsis Meliolae Hansford.
Eriomycopsis minima Hansford.
Eriomycopsis robusta Hansford.
Eriomycopsis Schiffnerulae Hansford.
Eriomycopsis Sclerochitonis Hansford.
Eriomycopsis Trichiliae Hansford.
Helminthosporium dorycarpum Mont. (the 3-septate species included here have not yet been sorted satisfactorily into separate species).
Helminthosporium capense Thum. (=*H. Coffeae* Mass., etc.)
Dendryphium Loranthi Hansford.
Cercospora Chandleri Hansford.
Cercospora sp., *Hansford 2609.*
Isaria Meliolae Hansford.
Arthrosporium parasiticum Wint.
Arthrobotryum melanoplaca B. & C.
Arthrobotryum ugandensis Hansford.
Spegazzinia Meliolae Zimm.
Spegazzinia Chandleri Hansford.

MUCOR sp.
Piptocephalis Freseniana De Bary & Woron, var. *Macrospora* Hansf, Ined.

MICROTHYRIACEAE
Gloeopeziza ugandensis Hansford.
Eriomycopsis angustispora Hansford.
Eriomycopsis Asterinae Hansford.
Verticicladium ugandense Hansford.

OIDIUM spp.
Cicinnobolus Cesati De Bary.

PHYLLACHORACEAE
Dendrodochium coniosporiicola (P. Henn.) Hansford.
Didymopsis Phyllachorae Syd.
Cryptodidymosphaeria clandestina Syd.

SCHIFFNERULA spp.
Acremoniella Sarcinellae Pat. & Har.
Titaea Ugandae Hansford.
Cercospora sp., *Hansford 3120.*
Eriomycopsis Schiffnerulae Hansford.
Chaetodimerina Schiffnerulae Hansford.
Dimerium pulveraceum (Speg.) Theiss.
Phaeophragmeriella clavisporum (Syd.) Hansford.
Loranthomyces ugandensis Hansford.
Eriomycopsis flagellata Hansford.
Eriomycopsis Ugandae Hansford.

SEPTOIDIUM LATERITIUM (Syd.) Arnaud.
Stigmina Septoidii Hansford.
Cephalosporium sp.

UREDINEAE
Eudarluca australe Speg.
Darluca filum (Biv.) Cast.
Verticillium sp.
Cladosporium Hemileiae March. & Stey.
Cephalosporium sp.
Tuberculina persicina (Ditm.) Sacc.
Cercosporella sp.
Titaea sp.
Paranectria Hemileiae Hansford.

USTILAGINEAE
Fusarium paspalicola P. Henn.
Fusarium moniliforme Sheldon.

USTULINA sp.
Nectria vilior Starb.

SPHACELIA spp.
Cerebella Andropogonis Ces.

GYMNOSPERMAE

ENCEPHALARTOS sp.
Camarorporium sp.

CUPRESSUS spp.
Rhizoctonia lamellifera Small.

PODOCARPUS MILANJIANUS
Corynelia clavata (L.) Sacc., f. *macrospora* Syd.
Corynelia uberata Fries.
Rhizoctonia lamellifera Small.

DICOTYLEDONES

ANNONACEAE

ANNONA spp. (Cultivated)
Colletotrichum sp.
Glomerella cingulata (Stonem.) Spauld. & v. Schrenk.
Phyllosticta sp.
Rhizoctonia lamellifera Small.
Triposporium sp.

ARTABOTYS spp.
Asterina Artabotrydis Hansford.
Chaetothyrium sp., *Hansford 3054.*
Lecideopsella ugandensis Hansford.
Micropeltis spiralis Hansford.
Micropeltis Ugandae Hansford.
Meliola Artabotrydis Hansford.
Sphaerophragmium Artabotrydis Doidge.

MONODORA GIBSONI
Meliola Monodorae Hansford.

POPOWIA spp.
Meliola borneensis Syd.
Meliola Maitlandii Hansford.
Asterina sp.
Aecidium Popowiae P. Henn.

UVARIA spp.
Dothidella Uvariae Hansford.
Meliola borneensis Syd.
Meliola ramicola Hansford.
Asterina Uvariae Hansford.
Eremotheca ugandensis Hansford.
Chaetothyrium sp., *Hansford 3071.*
Sphaerophragmium Artabotrydis Doidge.

MONIMIACEAE

XYMALOS sp.
Monilia borneensis Syd.

LAURACEAE

PERSEA AMERICANA
Glomerella cingulata (Stonem.) pSauld. & Schrenk.
Colletotrichum sp.
Nematospora gossypii Ashby & Nowell.

MYRISTICACEAE

PYCNANTHUS sp.
Asterina Pycnanthi Hansford.
Meliola uncinata Syd.
Clypeolum sp.

RANUNCULACEAE

CLEMATIS sp.
Aecidium englerianum Henn. & Lind.
Coleosporium Clematidis Barclay.

RANUNCULUS sp.
Aecidium sp.

NYMPHAEACEAE

NYMPHAEA sp.
Cercospora sp.

MENISPERMACEAE

CISSAMPELOS sp.
Dimerella Cissampeli Hansford.
Meliola Cissampeli Hansford.
Schiffnerula sp.
Schneepia Cissampeli Hansford.
Lachnum sp.
Cercospora kampalensis Hansford.

PIPERACEAE

PIPER sp.
Amazonia ugandensis Hansford.
Irenina atra (Doidge) Stevens.
Meliola stenospora Wint.
Elsinoe Piperis Hansford.
Asterina elachista Syd.
Asterina sp.

CAPPARIDACEAE

CADABA sp.
Asterina sp.

CAPPARIS sp.
Irenopsis Bosciae (Doidge) Stevens.
Asterina Capparidis Syd. & Butl.
Asterina capparidicola Doidge.
CLEOME sp.
Peronospora Cleomes Hansf.
MAERUA sp.
Asterina capparidis Syd. & Butl.
Asterina sp.

CRUCIFERAE

BRASSICA sp.
Peronospora parasitica (Pers.) De Bary.
Alternaria circinans (B. & C.) Bolle.
Cercospora brassicicola P. Henn.
Oidium sp.

VIOLACEAE

VIOLA sp. cult.
Cercospora Violae Sacc.

POLYGALACEAE

CARPOLOBIA sp.
Meliola Carpolobiae Hansford.
POLYGALA sp.
Uromyces Polygalae Grove.

CARYOPHYLLACEAE

DIANTHUS sp.
Uromyces Dianthi (Pers.) Niessl.
Septoria Dianthi Desm.
Botrytis vulgaris (Lk.) Fr.
Heterosporium echinulatum (Berk.) Cooke.
Alternaria tenuis Bolle.
Fusarium caudatum Wollenw.
Fusarium oxysporum Schlecht., f.
Fusarium Solani (Mart.) Wollenw.
Sclerotium Rolfsii Sacc.
Rhizoctonia bataticola (Taub.) Butl.
Macrophomina Phaseoli (Maubl.) Ashby.
DRYMARIA sp.
Puccinia leptosperma Syd.

MOLLUGINACEAE

MOLLUGO sp.
Cystopus sp.

PORTULACACEAE

PORTULACA sp.
Cystopus Portulacae (Lev.) De Bary.

POLYGONACEAE

FAGOPYRUM ESCULENTUM
Peronospora ducometi Siem. & Jank. ("*Botrytis* sp." in previous Host List).
Phyllosticta sp.
Cercospora polygonacea Ell. & Ev.
POLYGONUM sp.
Ustilago utriculosa (Nees) Tul.
Uromyces Polygoni (Pers.) Fuckel.
Puccinia Polygoni-amphibii Pers.
Uredo sp.
RUMEX sp.
Uredo of *Oromyces Rumicis* Wint.

PHYTOLACCACEAE

PHYTOLACCA sp.
Meliola Phytolaccae Hansf. & Stev.
Cercospora flagellaris Ell. & Mart. ("*C. Phytolaccae* Hansf.").
Oidium sp.

CHENOPODIACEAE

CHENOPODIUM sp.
Septoria Chenopodii West.
Cercospora anthelmintica Atk.

AMARANTACEAE

ACHYRANTHES sp.
Peronospora sp.
Cystopus bliti De Bary, f. *Achyranthis* P. Henn.
Uredo sp.
AMARANTHUS sp.
Cystopus bliti De Bary.
Cercospora Amaranthi Lobik.
CELOSIA sp.
Cercospora Celosiae Syd.
CYATHULA sp.
Uromyces Cyathulae P. Henn. (Uredo only).
Uredo Gomphrenae Barclay.

BASELLACEAE

BASELLA ALBA
Elsinoe sp. n.

LINACEAE

HUGONIA sp.
Asterina hapala Syd.
Dictyopeltis entebbeensis Hansford.
LINUM sp. cult.
Fusarium Lini Bolley.

GERANIACEAE

GERANIUM sp.
Uromyces Geranii (DC) Otth. & Wartm.
Puccinia Gerania-sylvatici Karst.
PELARGONIUM sp.
Pythium ultimum Trow.
Fusarium caudatum Wollenw.

OXALIDACEAE

OXALIS sp.
Oidium sp.
Mycosphaerella depazaeformis (Ces. & De Not.) Wakef.
Cercospora corniculatae Hansford.

TROPAEOLACEAE

TROPAEOLUM
Oidium sp.
Cercospora Tropaeoli Atk.

PUNICACEAE

PUNICA GRANATUM
Cercospora lythracearum Heald & Wolf.
Mycosphaerella lythracearum Wolf.

THYMELEACEAE

PEDDIAEA sp.
Irenopsis masakensis Hansford.

PROTEACEAE

GREVILLEA ROBUSTA
Nectria flavo-lanata B. & Br.
Rhizoctonia lamellifera Small.
PROTEA sp.
Leptosphaeria protearum Syd.
Hendersonia protearum Wakef.

DILLENIACEAE

DILLENIA INDICA
Pestalozzia sp.
TETRACERA sp.
Uleomyces Tetracerae Hansford.
Hysterostomella Tetracerae (Rud.) v. Hoehnel.
Asterina scruposa Syd.
Phomachora sp.

PITTOSPORACEAE

PITTOSPORUM sp.
Meliola polytricha Kalchbr. & Cooke.
Asterina Hansfordii Syd.

BIXACEAE

BIXA ORELLANA
Oidium sp.
Rhizoctonia lamellifera Small.

FLACOURTIACEAE

CALONCOBA sp.
Irenopsis Caloncobae Hansford, Kivu, Congo).
DOVYALIS sp.
Meliola Scolopiae Doidge.
Irene natalensis (Doidge) Doidge.
FLACOURTIA sp.
Meliola Scolopiae Doidge.
HYDNOCARPUS sp.
Armillaria mellea (Vahl) Fries.
Septoria sp.
ONCOBA sp.
Irene natalensis Doidge.

PASSIFLORACEAE

ADENIA sp.
Schiffnerula mirabilis v. Hoehnel.
Elsinoe Adeniae Hansford.
Heterosporium Adeniae Hansford.
PASSIFLORA spp.
Schiffnerula mirabilis v. Hoehnel.
Cercospora truncatella Atk.

CUCURBITACEAE

CUCUMIS spp.
Oidium sp. (*Erysiphe cichoracearum* DC).
Rhizoctonia bataticola (Taub.) Butl.
MELOTHRIA sp.
Septoria cucurbitacearum Sacc. f. *macrospora* Wakef.
MOMORDICA sp.
Septoria cucurbitacearum Sacc., f. *macrospora* Wakef.
TELFAIRIA PEDATA
Capnodium sp.
Phyllosticta sp.
Pythium ultimum Trow.
Indet. Hosts.
Aecidium sp.
Cercospora citrullina Cooke.

BEGONIACEAE

BEGONIA sp.
Bacterium tumefaciens E. F. Sm.
Cercospora sp.

CARICACEAE

CARICA PAPAYA
Oidium Caricae Noack.
Glomerella cingulata (Stonem.) Spauld. & Schrenk.
Cercospora papayae Hansford.
Mycosphaerella Caricae Maubl. (?)
Colletotrichum sp.
Fusarium oxysporum Schlecht.
Chloridium sp.
Pythium sp.

THEACEAE

THEA SINENSIS
Nectria Binotiana Sacc.
Elsinoe Theae Bitanc. & Jenkins.
Fomes lamaoensis Murr.
Armillaria mellea (Vahl) Fries.
Colletotrichum Camelliae Massee.
Pestalozzia Theae Saw.
Rhizoctonia lamellifera Small.

MYRTACEAE

EUCALYPTUS sp.
Armillaria mellea (Vahl) Fries.
Rhizoctonia lamellifera Small.
EUGENIA sp.
Tryblidiella rufula (Spreng.) Sacc.
Tubercularia sp.
Asterina bukobensis Hansford.
PSIDIUM GUAJAVA
Armillaria mellea (Vahl) Fries.
Glomerella cingulata (Stonem.) Spauld. & Schrenk.

MELASTOMACEAE

DISSOTIS sp.
Irenina melastomacearum (Speg.) Stevens.
Pucciniosira Dissotidis Wakef.
OSBECKIA sp.
Irenina melastomacearum (Speg.) Stev.
TRISTEMMA sp.
Puccinia necopina Grove.

COMBRETACEAE

COMBRETUM sp.
Irenina laguncularíae (Earle) Stevens.
Asterina Combreti Syd.
Meliola sp. indet.

HYPERICACEAE

HARUNGANA sp.
Hemileia sp.
Irenia Harunganae Hansford.
Acrotheca Harunganae Hansford.
HYPERICUM sp.
Uromyces Hyperici-frondosi (Schw.) Arth.
Uredo Hyperici-Schimperi P. Henn.

GUTTIFERAE

SYMPHONIA sp.
Irenina mangostana (Sacc.) Stev.

TILICEAE

CORCHORUS sp.
Macrophomina Phaseoli (Maubl.) Ashby.
Alternaria macrospora Zimm.
GLYPHAEA sp.
Irenina Glyphaeae Hansford.
GREWIA sp.
Asterina nyanzae Hansford.
Phyllachora Grewiae (Kalchbr.) Theiss. & Syd. (?)
Mycosphaerella sp.
Uredo Grewiae Pat. & Har.
Verticicladium Grewiae Hansford.
HONCKENYA sp.
Phyllachora Grewiae (Kalchbr.) Theiss. & Syd. (?)
Irenopsis coronata (Speg.) Stev., var *Vanderystii* Beeli.
TRIUMFETTA sp.
Irenopsis coronata (Speg.) Stev., var. *Triumfettae* Stev.
Asterina sp.
Uromyces sp.
Helminthosporium Triumfettae P. Henn.
Cercospora Triumfettae Syd.
Verticillium Dahliae Kleb.

STERCULIACEAE

ABROMA AUGUSTA
Cercospora Abromae Hansford.
Verticillium Dahliae Klebahn.
Fusarium spp.
DOMBEYA sp.
Phyllachora Dombeyae Syd.
STERCULIA sp.
Nematospora Gossypii Ashby & Nowell.
THEOBROMA CACAO
Phytophthora palmivora Butl.
Didymosphaeria sp.
Nectria flavo-lanata B. & Br.
Calonectria rigidiuscula (B. & Br.) Sacc.
Glomerella cingulata (Stonem.) Spauld. & Schrenk.
Helicobasidium longisporum Wakef.
Armillaria mellea (Vahl) Fries.
Rhizoctonia lamellifera Small.
Septoria sp.
Phlyctaena anomala Petch.
Phyllosticta sp.
Colletotrichum theobromicolum Del.
Cephalosporium sp.
Fusarium decemcellulare Brick.
Stilbella sp.
Stachybotrys Theobromae Hansford.
Trichosphaeria sp.
Botrytis sp.

MALVACEAE

ABUTILON sp.
Puccinia Abutili B. & Br.
Puccinia heterospora B. & C.
Nematospora Gossypii Ashby & Nowell.
Cladosporium anomalum B. & C.
GOSSYPIUM HIRSUTUM
Bacterium malvacearum E. F. Sm. (*Xanthomonas malvaceara* Dowson).
Bacterium spp.
Nematospora gossypii Ashby & Nowell.
Glomerella Gossypii Edgerton.
Mycosphaerella areola Ehrlich & Wolf.
Mycosphaerella gossypina (Atk.) Earle.
Kuehneola Gossypii Arth.
Phyllosticta gossypina Ell. & Mart.
Ascochyta Gossypii Syd.
Ascochyta sp.
Septoria gossypina Cooke.
Colletotrichum Gossypii South.
Verticillium Dahliae Kleb.
Verticillium sp.
Alternaria gossypina.
Alternaria tenuis Bolle.
Alternaria macrospora Zimm. f.
Cercospora gossypina Cooke.
Cercosporella Gossypii Speg.
Fusarium acuminatum E. & Ev.
Fusarium moniliforme Sheld.
Fusarium oxysporum Schlecht.
Rhizoctonia bataticola (Taub.) Butl.
Rhizoctonia Solani Kuhn.
Sclerotium Rolfsii Sacc.
Macrophomina Phaseoli (Maubl.) Ashby.
Corticium vagum B. & C.
Pythium ultimum Trow.

Boll Rots due to Bacteria (various), *Aspergillus* spp., *Penicillium* spp., *Chaetomium globosum* Kunze, *Chaetomium indicum* Corda, *Diplodia gossypina* Cooke, *Diplodia Theobromae* Pat., *Monilia sitophila* (Mont.) Sacc., *Rhizopus nigricans* Ehrenb., have been recorded in Uganda, but most of these organisms are probably saprophytic following *Xanthomonas malvaceara*, as is that due to *Glomerella Gossypii* in most cases.

HIBISCUS sp.
Nematospora Gossypii Ashby & Nowell.
Aecidium Garckeanum P. Henn.
Aecidium erythrobasis B. & Br.
Puccinia exilis Syd. var. *Hibisci* Grove.
Phyllosticta hibiscina Ell. & Ev. (?)
Cercospora Hibisci Tracy & Earle.
Cercospora hibiscina Ell. & Ev.
Fusarium oxysporum Schlecht., f.
Verticillium Dahliae Klebahn.
Rhizoctonia Solani Kuhn.
Rhizoctonia bataticola (Taub.) Butl.
Bacterium sp. (Fruit rot of *H. esculentus*).
Irenopsis coronata (Speg.) Stevens, var. *Triumfettae* Stevens.
Irenopsis coronata (Speg.) Stevens, var. *Hibisci* Hansford & Stevens.
Irenopsis coronata (Speg.) Stevens, var. *Vanderystii* Beeli.
Irenopsis Molleriana (Wint.) Stevens.
Bacterium Hibisci Nak. & Tak.
Dactylosporium Hibisci Hansford.

SIDA sp.
Asterina diplocarpa B. & C.
Puccinia heterospora B. & C.
Helminthosporium sp. near *H. Triumfettae* P. Henn.

URENA sp.
Irenopsis coronata (Speg.) Stev., var. *Triumfettae* Stevens.

EUPHORBIACEAE

ACALYPHA sp.
Irenina Hansfordii Stevens.
Meliola Chandleri Hansford.
Calonectria guarapiensis Speg.
Chaetothyrium Acalyphae Hansford.
Asterina radio-fissilis (Sacc.) Theiss.
Melampsora Acalyphae Petch.
Puccinia Acalyphae Doidge.
Dimeriella lichenicola Hansford.

ALCHORNEA sp.
Irenina entebbeensis Hansford & Stevens.
Asterina kampalensis Hansford.
Micropeltella Alchorneae Hansford.
Micropeltis corynespora Sacc.
Micropeltis Ugandae Hansford.
Eremotheca philippinensis Syd.
Aulographum sp.
Argyriopsis javanica v. Hoehnel.
Skierka congensis P. Henn.
Aecidium sp.
Phaeosaccardinula Canthii Hansford.

ANTIDESMA sp.
Puccinia aequalis P. Henn.
Irenina glabra (B. & C.) Stevens.
Echidnodes sp.
Pestalozzia sp.

ARGOMUELLERA sp.
Uredo sp.

BRIDELIA sp.
Meliola brideliicola Hansford.
Schiffnerula Brideliae Hansford.
Asterina sp.
Microthyriella scabrella Syd.
Cercosporella sp.

CLUYTIA sp.
Uromyces Cluytiae Kalch. & Cke.
Uromyces Cluytiae K. & C., var. *minor* Wakef.
Aecidium Cluytiae Wint.

CODIAEUM sp.
Rhizoctonia lamellifera Small.

CROTON sp.
Skierka congensis P. Henn.
Meliola Alchorneae Stev. & Tehon.
Meliola micropoda Hansford.
Rosenschieldiella ugandense (Syd.) Hansford.

ERYTHROCOCCA sp.
Irenina sp. indet.
Asterina sp.

EUPHORBIA sp.
Peronospora valesiaca Gaum.
Oidium sp.
Meliola ugandensis Hansford.
Meliola Teke Hansford.
Eremotheca philippinensis Syd.
Uromyces proeminens (DC) Lev.
Melampsora sp.
Helminthosporium Euphorbiae Hansford.
Alternaria sp.
Cercospora euphorbiaecola Atk.
Cercospora pulcherrimae Tharp.

HEVEA BRASILIENSIS
Oidium Heveae Steinm.
Eutypella Heveae Yates.
Ceratostomella fimbriata.
Helicobasidium longisporum Wakef.
Armillaria mellea (Vahl) Fries.
Pomes lamaosensis Murr.
Phyllosticta Heveae Zimm.
Phoma Heveae Petch.
Placophomopsis Heveae Grove.
Gloeosporium albo-rubrum Petch.
Pestalozzia palmarum Cooke.
Tubercularia versicolor Sacc.
Stilbella cinnabarina (Mont.) Sacc.
Rhizoctonia lamellifera Small.

MACARANGA sp.
Irenopsis Macarangae Hansford.
Irenina entebbeensis Hansford & Stevens.
Scolecopeltis sp.
Asterina kampalensis Hansford.
Oomyces sp.
Cocconia Macarangae Hansford.
Phaeaspis nervicola Hansford.
Englerula Macrangae P. Henn.

MALLOTUS sp.
Irenina Hansfordii Stevens.

MANIHOT UTILISSIMA
Bacterium Cassavae Hansford.
Armillaria mellea (Vahl) Fries.
Cercospora Henningsii Allesch.
Verticillium Dahliae Klebahn.
Fusarium oxysporum Schlecht., f.
Mosaic Disease.

MICROCOCCA sp.
Aecidium sp.

PHYLLANTHUS sp.
Aecidium Phyllanthi P. Henn.
Cercospora Phyllanthi Hansford.

RICINUS COMMUNIS
Melampsora Ricini Pass.
Alternaria Ricini (Yoshii) Hansford.
Cercospora ricinella Sacc. & Berl.
Myrothecium sp.

SAPIUM sp.
Parodiopsis Perae Arnaud.
Irenina entebbeensis Hansford & Stevens.
Cercospora sapiicola Speg.
Septoidium lateritium (Syd.) Arnaud.

TRAGIA sp.
Puccinia Tragiae Cooke.

ROSACEAE

ALCHEMILLA sp.
Uromyces Alchemillae (Pers.) Lev.

ERIOBOTRYA JAPONICA
Ascochyta Eriobotryae Vogl.

PARINARI sp.
Phaeochorella Parinarii Theiss. & Syd.

PRUNUS PERSICA
Puccinia Pruni-spinosae Pers.

ROSA sp.
Sphaerotheca Humuli (DC) Burr.
Diplocarpon Rosae Wolf.
Armillaria mellea (Vahl) Fries.
Coniothyrium Fuckelii Sacc.
Cercospora rosicola Pass.
Stagonospora Rosae Brun.
Rhizoctonia bataticola (Taub.) Butl.
Bacterium tumefaciens E. F. Sm.

(*To be continued*)

SUPPLEMENT
to the East African Agricultural Journal
(April, 1943)

THE AGRICULTURAL EDUCATION OF A PRIMITIVE TRIBE: THE WEST SUK OF KENYA

By G. H. Chaundy, M.B.E., B.Sc., Agric. (Lond.), Education Officer, Kenya Colony

Introduction

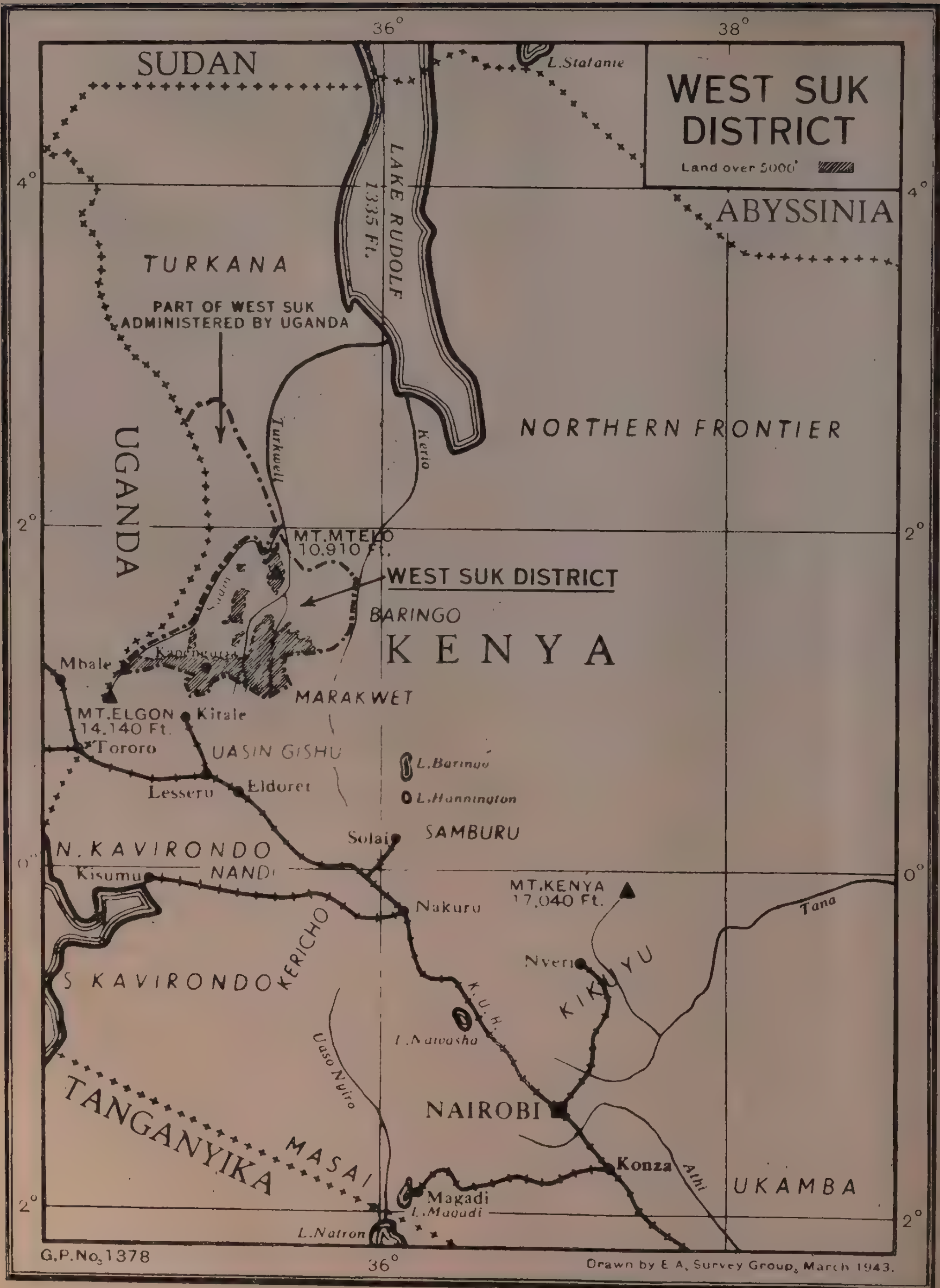
The West Suk District lies to the north-west of Mount Elgon, and is over 5,000 square miles in area. To the north is the Turkana District, which is little less than a sandy desert, to the west, Uganda and to the south the Trans Nzoia settled area and Marakwet. On the east is Baringo District where the East Suk live. In 1932 that part of West Suk to the west of the Suam River, an area of approximately 2,000 square miles, was handed over to Uganda and is now administered from Moroto in Karamoja. Thus the area of the country about which this article is written is 3,300 square miles with a population of 21,000.

From a topographical point of view the West Suk District can be conveniently divided into four parts: The Serkerr Massif in the north, the highest peak of which is Mtelo (10,910 ft.); the Southern Hills, including the Sondang range and part of the Cherangani Hills, which rise to over 10,000 ft.; the Eastern Plain, between the sharply defined eastern edge of the hills and the Southern Turkana boundary at an altitude of 3,000 ft.; and the Western Plain, the altitude of which is 4,000 to 5,000 ft. There are large areas of good agricultural land in the plains, and on plateaux in the hills.

Apart from the Suam, which rises on Mount Elkon and is the present western boundary, all the main rivers come from the forested summits of the Cherangani Hills, and flow into Lake Rudolf. The chief of these are the Murun, which, after being joined by several small mountain streams, becomes the Marich and flows through the pass of that name, the Weiwei, which is joined by the Marich and later by the Suam to form the Turkwell, and the Seigha which flows into the Weiwei after crossing the Masol Plain. All these rivers are permanent.

The climate varies with the altitude from the tropical heat of the plains to the comparatively cool areas above 7,000 ft. On the top of the Sondang Mountains, where the altitude varies from 9,000 to 10,000 ft. frosts are experienced at night, but this region is uninhabited. At the height of the dry season, when there is little grazing left below, the Suk occasionally take their stock to browse over these open windswept heaths. There is a long rainy season from April till October, followed by a marked dry season. The plains receive 20 in. to 30 in. of rain a year, and the agricultural areas between 6,000 and 7,000 ft. 40 in. to 60 in., whilst in the higher regions of the Cherangani and Sondang Hills the rainfall is as heavy as 80 in. per annum. The long dry season has many disadvantages, and has been one of the primary causes of erosion in the past. The grass cover dries up, and if the stock do not eat it off, the termites take their toll. The people used to burn the dry grass in the hills every year so as to get a bite of fresh young grass for their stock, and this caused erosion, especially on mountain slopes. The fires often used to spread to the forests and large areas were destroyed in this way, which gradually affected the flow of the mountain streams. The rainfall is ample both for cultivation and the growth of pasture during the rains, but grazing becomes short in the dry season. It is of the utmost importance to see that the forests are not destroyed or else the rivers which rise in these forests will no longer be permanent.

Count Teleki, who discovered Lakes Rudolf and Stephanie, seems to be the first European to give any account of the Suk. Together with Lieut. Von Hoehnel, an officer of the Austrian army, he set out from the coast in 1887 with about 400 porters, and his adventures are given in a book written by Van Hoehnel. These two pioneers had several exciting encounters with the Kikuyu and Masai. They eventually reached Lake Baringo, where they bought food from the Njemps, and trekked north towards Turkana. Besides discovering Lakes Rudolf and Stephanie, they found an active volcano south of Lake Rudolf, which is called Teleki's Volcano. On


WEST SUK DISTRICT
Land over 5000'
SUDAN
ABYSSINIA
L.Stafanie
LAKE RUDOLF
1335 Ft.
TURKANA
PART OF WEST SUK ADMINISTERED BY UGANDA
UGANDA
Turkwell
Kerio
NORTHERN FRONTIER
MT.MTELO
10,910 Ft.
WEST SUK DISTRICT
BARINGO
KENYA
Mbale
MARAKWET
MT.ELGON
14,140 Ft.
Kitale
Tororo
UASIN GISHU
L.Baringo
Lesseru
Eldoret
L.Hannington
Solai
SAMBURU
N.KAVIRONDO
Kisumu
NANDI
MT.KENYA
17,040 Ft.
Nakuru
Tana
KERICHO
S KAVIRONDO
Nyeri
KIKUYU
K.U.R.
L.Naivasha
Uaso Nyiro
NAIROBI
TANGANYIKA
MASAI
Konza
Athi
UKAMBA
Magadi
L.Magadi
L.Natron
G.P.No.1378
Drawn by E.A. Survey Group, March 1943.

the way back they followed the Turkwell River, and then came into West Suk to buy food, as they heard the millet (*Sorghum*) crop was ripe. But when they got to Weiwei, they found the crop was not ready. Count Teleki said the Suk were bold raiders, and he had to keep a guard on his camp at night. The Suk call themselves "Pokwut." "Suk" is the name applied by the Masai to the people who lived in the hills, because they carried a "chok," which is the name of a short curved bill-hook. A long time ago the original Suk lived in the high country towards the western end of the Cherangani Hills and on the Serkerr Massif. These hill dwellers lived on finger millet (*Eleusine coracana*) honey and game which they killed with arrows. They dared not descend to the plains because the Samburu were in the Kerio Valley, and the Turkana farther west. Local tradition says that a Suk wizard prepared a charm which he placed in the Samburu cattle kraals with a result that large numbers of their cattle died. Probably this was due to an outbreak of disease such as rinderpest. However, the Samburu left the Kerio valley, and went eastwards. The Suk then descended from the hills, occupied the land vacated by the Samburu, and captured some of their cattle. They pushed as far as the Tiati Hills but were prevented from going further by the war-like Masai. The Suk then made friends with the Turkana, and raided the Njemps. This happend about 70 years ago. Then they quarrelled, and of late the history of the Suk is mostly concerned with quarrels with the Turkana, the latter usually getting the better of the argument. Thus the Suk of the present day are descendants of the original hill dwellers, who have intermarried with the Turkana, Karamojong, Cherangani and Marakwet. We see a large number of types represented from the tall handsome Hamite to the dwarf type with spread nose. This latter type is particularly noticeable amongst the Hills Suk of the present day. During the last few years the Suk have been on good terms with the neighbouring tribes, and under British rule are living peacefully, turning their attention to more enlightening pursuits than cattle raiding. Much has been achieved in this direction, as will be seen from the following pages, but it is only the beginning of far greater progress that should be made in the future, so that the African will be fitted to take his place in the world of to-day.

Before the Europeans came to this country, there was little tribal organization amongst the Suk on which to build for future advancement. There was no hereditary system of kings or chiefs as in some other parts of Kenya and in Uganda. At first the people did not welcome the chiefs appointed by Government, and did little to co-operate with them. This has largely been overcome during the last few years, as more enlightened men have been appointed, and the people are seeing for themselves the benefits of the various schemes put into operation for their well-being.

It has often been said that we are teaching the African to run before he can walk, and from my experience I consider real progress will only be made if it is built on a firm foundation. Backward people like their medicine in small doses, and it is of little use trying to start too many new schemes at once, although one might think they are all equally important for the good of the tribe. Again, any European working amongst such people should get to know their customs and mode of life; if he is ignorant of them, however well intentioned he is, he may do something which will cause them to distrust him for ever. Progress should come from the people themselves, but he can do much to win their support for advancement by practical demonstrations, especially in the field of agriculture and stock husbandry. With these thoughts in my mind, I returned from my first tour of the West Suk District in February 1931, and the following pages explain what has happened since then.

The Starting of Education in West Suk

Before the year 1930 little had been done to improve the conditions of the West Suk tribe. No Europeans were working in the district except Administrative Officers, whose time was occupied mainly in preventing inter-tribal raids. When I was posted to this district in January 1931, my first duties were "to make a close study of the Suk, with respect to the best methods to adopt in the new school to help them socially and economically." From February to May of that year extensive tours of the district were undertaken on foot. In a letter the District Commissioner wrote, "The Suk are very backward and conservative to a degree, and it will be a long uphill task to win their confidence and secure any active interest and support from them to any scheme which may be inaugurated for their benefit". At this time they were definitely famine-stricken, as little or no rain had fallen since the previous September and locusts had eaten their first crop of *Sorghum*. Even the pastoral Suk were not getting

enough to eat, as there was little grazing for the cattle owing to the prolonged drought, and they were unable to obtain any grain from the agricultural section, which they usually did during a dry time. People were eating wild berries, rats, baboons and in fact anything they could find. It was seen that their agricultural methods were primitive in the extreme, and large areas of forested land near the headwaters of streams were being destroyed every year. There was no controlled grazing, and in the dry season stock congregated near water-holes, around which the grass cover had already disappeared. As a result of these tours I came to the conclusion that something ought to be done to improve the conditions of the people in the reserve and to stop them from destroying their country, in addition to conducting a school at Kapenguria for their sons. Owing to lack of funds, the maximum number of pupils that could be accommodated was 60, and it was felt that this would not have much effect for some considerable time upon the West Suk tribe with a population of 23,000. In this article I want to show how the work undertaken has not only benefited the boys who have been through the school, but the whole tribe. It will also be seen how the ex-schoolboys have helped to attain this.

In October 1929 an African teacher was posted to Kacheliba, then the administrative headquarters of the district. A hut, which was built during the locust campaign to store equipment, was used as a schoolroom. There was no educational equipment, but slates were borrowed from the Police School. Boys came in from various parts of the reserve, and on 31st December, 1929, there were 25 on the roll. At that time there were no missions working in West Suk, so the whole tribe was illiterate. It had been decided to move the station to Kapenguria because Kacheliba was unhealthy for Europeans, and the West Suk Local Native Council voted a sum of £650 to build a permanent school there. The Director of Education agreed to help with material and to undertake the building. In January, 1930, a leading artisan with a gang of apprentices from the Native Industrial Training Depot, Kabete, arrived, and started building in burnt brick. In February the school at Kacheliba was closed, and the pupils transferred to Kapenguria where they were accommodated in temporary huts for the meantime. By September their numbers had dwindled to eight, and they ran away because they found Kapenguria cold after Kacheliba. A school building comprising two classrooms was completed in June, and by the end of the year a dormitory to accommodate 30 boys was ready. As a result of tours made in the district during the early part of 1931, it was considered that if the boys had an elementary literary education with a training in practical agriculture, it would fit them not only to become successful peasant farmers, but also to be a good influence on the whole community.

When the school reopened after the holidays in January, 1931, 22 boys came back out of 30 on roll. A site was selected for a school garden, and in the afternoons the boys prepared it for planting. They became very interested in this work and wanted to start gardens of their own. A small area was fenced off, but they soon dug it over and asked to be allowed a larger garden. Apart from other crops, a particularly heavy yield of English potatoes was obtained, and after being shown how to cook and prepare them, the boys soon found they were sweet to the tooth.

The chiefs and elders often visited the school, and were given produce from the school gardens to sample. They called the school "The place where you eat potatoes," and several of them brought their sons to be admitted. By the end of the year there were 50 boys on the roll. Eight of the brightest boys were selected, and given intensive training in practical agriculture in readiness for taking up work in the district. The progress of the school has been maintained each year, and many of the former pupils are now successful farmers.

Primitive Agricultural Methods of the Tribe

It was found that the tribe could be divided into:—

(*a*) The pastoral Suk, who possessed cattle. They inhabited the plains round Kacheliba, Kipkomo, Masol, and Batei, but over large areas the grass cover was disappearing and desert conditions setting in through overgrazing. They cultivated small plots of finger millet on the steep hillsides, and were gradually deforesting many of the catchment areas down which the streams ran. Their chief food was milk and blood, but the finger millet was used during the dry season when milk was scarce. They also bled their cattle in the dry weather. Meat was only eaten on special occasions. During a prolonged drought grain was obtained from the agricultural section.

(*b*) The agricultural or hills Suk, who had little or no stock with the exception of goats.

They lived on the steep hill-slopes, and practised a primitive form of agriculture. Only two food crops were grown, finger millet on the steep hillsides and *sorghum* on the flat land near the main streams.

Finger Millet.—Patches on the steep hillsides were chosen in the dry season, and the undergrowth cut down. This was piled round any large trees and fired, thereby destroying the majority of them. After burning the undergrowth, grass, etc., the land was merely scratched over with a primitive hoe or digging stick. As soon as the long rains started the seed was broadcast, and owing to the steepness of the slopes the seed as well as the top soil, was often washed away after a heavy downpour and a series of gullies formed. Steep hillsides were chosen as the local people say that when grown on the flat, the finger millet is attacked by a disease called *cheptaita* (ear blast), a rotting of the developing "fingers," which, as a result, do not set seed. Forest land was chosen because after burning the trees, the ash had a beneficial effect on the crop. It was planted at altitudes varying from 5,000 to 8,000 feet, and was harvested four to five months after planting. This was a laborious business, the individual ears being cut off by hand. After harvesting the patch was left, and next year another piece of the forest was destroyed and the land prepared for planting. On most of the steep hillsides in West Suk bare patches could be seen where the soil had been washed away leaving rocks exposed—the sites of former *shambas*. It was soon realized that this primitive method of agriculture was gradually reducing the forested slopes to bare rocky wastes, and the streams were drying up. After the seed had been planted and before the crop had time to take root, extensive erosion took place. The people were also destroying the forests on the banks of the streams running down the hillsides. At this stage it was useless to prohibit the cultivation of hillsides before teaching the people better methods of agriculture. Finger millet had been one of their staple foods for generations; it is nutritious and will stand storing for a considerable time.

Sorghum.—In the locations of Mwina, Weiwei, Lomut, Cheptulel and Marich there was a definite system of land tenure in contrast to the pastoral locations where all grazing was communal. Two crops of *sorghum* were grown per year, one planted in April or May and harvested in September, and the other planted in October and harvested in February or early March. For the growth of the first crop the people relied on the rains, and irrigation was only resorted to when there was a dry period, but the second crop, though planted before the rains usually stopped, was irrigated during its later growth. It was a crude but effective form of irrigation, and by the large trees seen along the banks of the furrows, it must have been practised for a considerable time. Main furrows were dug from the streams coming down from the Cherangani Hills just before they flowed to the plains. These main furrows were taken out roughly at right angles to the streams, and from them smaller furrows were constructed. In this way it was possible to irrigate a considerable area of flat land on the plains, and there was little soil erosion.

After harvesting the crop, the land was allowed to rest for two seasons, and reverted to bush, so that only one third of the available cultivable land was under a crop at one time. In this way the soil was not worked out; these light sandy soils rapidly lose their fertility if continually cropped without rotation or manuring.

When plots were prepared for planting the following procedure was carried out. The trees were merely lopped and not destroyed, the branches being used as fences. All undergrowth was cut, put into heaps and burned. The land was then dug with primitive hoes, a hard wood being sharpened and used for the blades. Very few people had metal hoes. While the women were digging, the men were opening up water furrows. Each family's plot was marked by boundary stones and often an irrigation furrow. As soon as the rains came, usually towards the end of April or early May, the seed was broadcast. When about six inches high the crop was thinned and weeded. It was the usual custom to leave too many plants, with the result that the crop was often badly "laid" during high winds or storms. When the crop was ripening, platforms were built on which children and women sat, scaring away birds. It was harvested towards the end of September by cutting off the ears. The women undertook the threshing. It was stored in the huts where the people lived, a platform being built for this purpose at about the height of the eaves.

Five distinct varieties of *sorghum* were grown at altitudes varying from 3,000 to 4,000 feet:—

Muruwon (meaning "dark coloured").—The grain is reddish brown; growing period from four to five months; heavy yielder.

Pakulipok ("large seed").—Grain reddish brown growing period four to five months·

For description of illustrations see page 7

heavy yielder. The Suk plant more of this than of the other varieties.

Piton ("quick to ripen").—Grain red; early maturing; growing period three to four months; usually planted in November if people are behindhand with work of preparing land for planting; only fair yielder.

Pkaran ("thin head").—Grain light in colour; growing period four to five months; particularly sweet, but not such a heavy yielder as *Muruwon* or *Pakulipok*.

Limuk ("covered ear").—Grain light brown and covered completely by the chaff; growing period four to five months; grain much harder than the others and not so readily eaten by birds.

The Start of Better Methods

Contrary to previous reports, it was found that many parts of Suk where agriculture was practised were well watered, and in a normal year the rainfall would be sufficient for the growth of a large variety of crops. Also there were fertile areas in some of the pastoral locations, and the people could be taught to cultivate there instead of on the steep hillsides. During several tours of the district in 1931 many meetings were held, and the advantages of introducing new crops were explained to the people.

Locusts caused great damage to the finger millet and *sorghum* in the years 1928 and 1930, and to a lesser extent in 1931. As a result of this there was a famine amongst the agricultural section of the tribe. Owing to the extreme apathy and conservatism of the people, they were averse to any new ideas and regarded with suspicion a European in their midst. A scheme was evolved towards the end of the year whereby small seed farms to try out new crops would be started in some of the agricultural locations. The District Commissioner was in sympathy with this scheme, but was rather sceptical of the whole thing, as he said the Suk were apathetic to a degree and to ensure success, constant supervision would be necessary.

In the meantime news had got round of the success of the schoolboys' gardens, and a large number of people visited the school, not to see how their boys were progressing, but to have a good feed. Every endeavour was made to impress on the chiefs and elders when they visited Kapenguria the urgent need for improving the food supply of the people in the reserve, as well as introducing improved methods of agriculture.

At a meeting of the Local Native Council held in August, 1931, I outlined a scheme for helping the people to increase and augment their food supply, and at the same time conserve their soil. This was that each location should have its own agricultural demonstration plot and seed-bulking farm. It was explained that the benefits would be threefold:—

To introduce new crops to the district.

To teach the people better methods of agriculture, special attention being paid to soil conservation.

To be a seed-distributing centre.

With the exception of one member, who said he would give it a trial, the majority of chiefs, owing to sheer laziness, said they did not welcome the suggestion.

Early in 1932 the Agricultural Department posted a native agricultural instructor to West Suk. He was a man who had been well trained, and also had much experience in the Kavirondo district under Agricultural Officers. He worked in the school at Kapenguria for a month, where he picked up a fair knowledge of the Suk language. Then he went on a tour of the district with me, and we chose a site

DESCRIPTION OF ILLUSTRATIONS

1. West Suk was overstocked and overgrazed with the result that the grasslands were becoming badly eroded.
2. Small plots on steep hillsides were gradually deforesting many of the catchment areas.
3. Pegging out ridges, using a line level.
4. Repairing a ridge.
5. The school gardens are run on mixed farming lines.
6. Plots are chosen on sloping land in order to teach the method of soil conservation.
7. Giving out groundnuts after harvest.
8. Drought resisting crops such as *njahi* (*dolichos lablab*) planted to give a soil cover.

for the first demonstration plot in the Mwina location. It was in a fertile valley at an altitude of 4,000 feet. At first the people were suspicious and put every conceivable obstacle in the way. They said I was sent out by the European farmers to see what crops would grow, and when it was proved what parts of the district were fertile, they would take the land from the natives. However, an area of about four acres was cleared and fenced. The native agricultural instructor's hut was built and the plot prepared for planting. It was difficult to get seeds and planting material out to the plot owing to the lack of motor roads. The Agricultural Department were most helpful in supplying seeds suitable to the altitude and climate. The first year the following crops were tried:—yellow maize (which was later interplanted with Rose coco beans), groundnuts, sweet potatoes, cassava, pigeon peas, and bananas.

When the crops were harvested they were given out to the people to sample, sufficient seed being retained. At the same time the proper ways of preparing and cooking the various foods were demonstrated. I might add that all the crops gave good yields, and, with the exception of pigeon pea, were readily eaten by the people. The natives in other locations soon heard that new crops were sweet to the tooth, and at a meeting of the Local Native ensure success constant supervision would be Council, held in August, 1932, various chiefs asked if demonstration plots might be started in their locations. They were informed that if they set aside money in the following year's estimate for the payment of ex-schoolboys to look after these plots, they would be started. The funds at the disposal of the council were meagre, but sufficient to pay boys in charge of these plots eight shillings per month. In the meantime special instruction was being given in agriculture to eight selected boys at the school so that they could take charge of these plots the following year.

Progress Made in the Reserve During 1933

Early in the year six more demonstration plots were started, with ex-schoolboys in charge. The sites were selected and personal supervision given to clearing, fencing and preparing for planting. There were now seven plots in all, three of which were in the hills (altitude 6,000 to 7,000 feet), where sub-tropical crops were grown, and the other four in the plains (altitude 3,000 to 4,000 feet). Owing to the broken nature of the country in the hills, the sites chosen for the plots were on sloping land, in order to teach the people methods of soil conservation. The work of the native agricultural instructor was now to tour the seven plots, and give advice to the ex-schoolboys in charge. As a general rule, I was only able to go on safari during the school holidays, and owing to the absence of roads these tours had to be undertaken on foot and lasted about three weeks. On each occasion meetings were held at each plot and the uses of the new crops under trial explained to the people. The anti-erosion measures in force on the various plots were also shown to everybody.

When the crops were harvested they were given to the people to sample, sufficient seed being retained for planting the next year. Crops they liked very much were planted more extensively the following year and anything they definitely disliked was discarded. For instance, they did not like the tubers of edible canna, nor, they stated, would their stock eat the leaves. On one plot awned bulrush millet was tried (the awned character was not fixed) and the people complained that it brought birds, so it was not tried again.

As far as is known, no medical officer had ever reported on the health of the people in the West Suk Reserve, but to the lay eye they seemed to be suffering from food deficiency diseases; ulcers and sores were common. This showed the necessity of introducing fruit and vegetables. Of the many different kinds of vegetables tried and then distributed to the people for sampling, onions, leeks, tomatoes, carrots and cabbage were approved.

At the end of the year very few people had grown any of the introduced crops. This was not surprising, considering the apathy and conservatism of the people. But the encouraging feature for future development was that they ate a number of these crops and, in time, would plant them in their own fields. Reports were sent in from time to time saying that bananas had been stolen from the plantations and potatoes, maize, groundnuts etc., taken from the stores.

Further Progress, and the Planting of Introduced Crops by the People

In 1934 another demonstration plot was started in the hills, an ex-schoolboy being placed in charge. The people had already planted maize, the seed of which was obtained from the demonstration plot in another location. The people of Kipkomo, a pastoral location, said that during the long dry season the

food problem became acute owing to the shortage of milk. A banana plantation was started in 1938, but they then wanted a demonstration plot with a large variety of crops. This was initiated in 1939, and the people at once started to clear *shambas* of their own on flat land nearby. Last year they reaped exceptionally heavy crops of maize, groundnuts, potatoes, sorghum, tobacco and *njahi* (*Dolichos lablab*). Formerly they planted a little finger millet on the steep hillsides near streams. The tenth and last demonstration plot was started at Chepunyal in the pastoral location of Sook in October 1939, and the people at once planted the seeds issued to them.

In the plains people started to plant maize, banana suckers, pawpaws, sweet potatoes and cassava. Although groundnuts were regularly given out for planting, none were seen growing. One day I met an old man after he had been issued with seed, and asked him what he had done with his groundnuts. He replied, "I really meant to eat half and keep half for planting, but I was hungry and the groundnuts were so sweet that I finished them all on my way home". In the hills English potatoes, maize, sweet potatoes, beans and tomatoes were among the first introduced crops planted by the people.

On all the demonstration plots contour ridges were made with sweet potatoes planted on them to bind the soil. The people were told that if the top soil is washed away they will not get good crops. Each able-bodied male works for a week each year on the plot in his location, so that approximately 5,000 men learn better methods of agriculture by "seeing and doing".

It is continually stressed at all meetings that if the people follow better methods of agriculture there is no need to practise shifting cultivation. Emphasis is laid on the following points: —

1. A definite rotation should be followed.

2. All crop residues should be dug in and not burnt.

3. Leguminous crops should be interplanted with maize and sorghum.

4. A leguminous crop should always follow the English potato crop.

5. If available, boma manure should be applied from time to time.

6. Before the onset of the dry season, drought-resisting crops such as *njahi* (*Dolichos lablab*), Madagascar butter beans, etc., should be planted to give a soil cover, and so prevent leaching. These crops should be dug in as green manure before the next rains, and so increase the amount of humus in the soil.

7. The people should see that there is no erosion on their *shambas*, by following the methods employed on the demonstration plots.

In 1938 the Local Native Council issued rules to stop forest destruction, cultivation on the steep hillsides and cultivation near streams. The Soil Conservation Service of the Agricultural Department allowed me funds for the employment of scouts, and their work has been most effective. Hillside cultivation has now virtually disappeared and a more fixed type of agriculture on flat land taken its place. All forests round the headwaters of rivers are protected. No cultivation is allowed there and the few people who formerly lived in these forests have been moved out.

The Treatment of Eroded Grazing

In the pastoral locations the people possessed too much stock. The Land Commission wrote: "We find it difficult to speak with moderation of the enormous numbers of stock which the Suk have been allowed to accumulate, and the problem thereby created is serious . . . Urgent measures are required and we recommend action on the following lines: —(*a*) An investigation should be made as to how the pasture land can best be reconditioned and the use of grazing be controlled, and action should be on whatever lines appear practical. This investigation might well be conducted by the Provincial Commissioner. (*b*) Such action as may be possible should be taken to reduce the area infested with tsetse fly, and so increase the grazing area. (*c*) Efforts should be made to reawaken the moribund tendency of the Suk to practise agriculture. (*d*) Immediate steps should be taken to reduce the number of stock."

But there was no outlet for this surplus stock as West Suk was a closed district and no animal could go out on the hoof. A Somali butcher slaughtered about three or four bullocks per week, and took their carcases to Kitale for sale. This was insignificant considering the total cattle population of the district. Thus West Suk was overstocked and overgrazed with the result that the grasslands were becoming badly eroded. I continually stressed the fact that things would go from bad to worse if an outlet was not found for the sale of surplus animals, but nothing was done until meat was required by the military authorities.

In one of the badly eroded areas where the vegetation cover had been almost lost, chiefly owing to overgrazing by goats, a plot of about an acre was enclosed in 1935. In three years it had recovered and the indigenous grasses had spread all over the plot. When the elders saw this they agreed to close the greater part of the eroded region by putting a thorn fence round it, an area of approximately 35 square miles. This was done in February, 1939. In January, 1940, a limited number of cattle were allowed in to graze over it and trample in the grass seeds. In 1941 further areas of eroded country, amounting to some 60 square miles in all, were enclosed. Grazing guards patrol these areas to see that no stock enter them. They are also in charge of tree plantations where experiments are being carried out to see what types of drought-resisting trees and fodder-plants will thrive. By resting the eroded grazing, thus giving it time to recover, and at the same time selling surplus stock, both cattle and goats, as is now being done, there is no fear of desert conditions ultimately prevailing in West Suk. On the contrary the grass cover will get better each year, providing the rainfall is normal and locusts do not pay too frequent visits.

Further Progress in Education

The first batch of boys only stayed for two years at the Kapenguria School, as they were needed for work in the reserve. In that time they had been taught to read and write, but in addition received a practical training in agriculture. Those not selected for posts as native instructors, hut counters etc., started smallholdings. The majority of smallholders made a great success of their venture and are now successful peasant farmers.

Each year more permanent school buildings were erected, and the school gardens were enlarged until they are now approximately 20 acres in extent. Besides the communal gardens, the produce of which goes into the school kitchen, each boy has his own plot where he puts into practice what he is taught in school. At the end of each year there is a produce show, which is staged entirely by the boys themselves. Last year the number of entries received for the various classes was 414, and the judge found it very difficult to award the prizes in some cases, as the produce was of such uniformly high quality.

The school gardens are run on mixed-farming lines, the manure from the herd being used to keep up soil fertility. Paddocks for the stock have been fenced to show how the grazing can be improved by this means. Fodder crops are grown for feeding during the dry season, and mangels have been a great success. They are fed during the dry months of January, February and March, thus keeping up the milk supply when there is little grass.

The handwork taught in the school is designed to be useful to the boys after they leave. In the lower classes string and rope are made from the bast of local shrubs and wild sansevieria, baskets are made from the Makindu palm (*Phoenix reclinata*) and elephant-grass stems (*Pennisetum purpureum*) and pottery work is also taught. Later on the boys learn rural carpentry and make such useful articles as seed-boxes, trays for sprouting potatoes, planting-sticks, wheelbarrows.

The Bible Churchmen's Missionary Society started a station at Kacheliba in 1932, and bought the vacated government houses and offices. Besides their religious work, they started a school. They found Kacheliba unhealthy and in 1935, moved to Nasokol only a few miles from Kapenguria. The Missionary in charge agreed to start village schools, if the people could be persuaded to support them, and I suggested the following educational programme for the Suk boys: two years in a village school, two years at the Nasokol School, and three years at the Government African School, Kapenguria. Naturally it would take some years to achieve this aim, and to give a large number of boys the full primary school course.

The first village school was opened at Sigorr in Weiwei location in June 1938, the Local Native Council having supplied Sh. 400 for its upkeep. In his annual report for 1938 the District Commissioner stated: "The local elders agreed to the school originally, but, when they realized that they would be expected to send their sons, their original enthusiasm dissolved into a willingness to suggest anyone's child but their own. However, at the end of the year the school, with considerable assistance from Government officers, had become firmly established, and a more or less regular attendance of 19 children was recorded."

The next school was opened in January 1940 at Tamkal in Mwina Location opposite the demonstration plot. This was a success from the start and the same may be said of the Kokwatantwa Village School started in January 1941. The aim of the Local Native Council is to provide funds to support an additional village school each year until there is one in each of the twelve locations. At the present time there are four such schools, the

fourth being started this year at Kongelai. The Local Native Council is spending £80 on these schools during the current year, and the amount will increase by £20 annually.

At all these village schools there are flourishing gardens complete with seed stores. The initial clearing and digging was done by the local people. The pupils receive simple practical instruction in preparing the land, planting, cultivating and harvesting various crops, special stress being laid on problems of soil fertility, rotation of crops, soil conservation. Vegetable cultivation is also undertaken and the boys are given fresh vegetables daily, which is a great benefit to their health.

The State of the Reserve at the Present Time, and Plans for Future Development

There is little likelihood of a food shortage in the future, owing to the fact that the people have planted a variety of crops. Banana suckers have been planted extensively in the plains and nearly every family has its own plantation. Other crops doing well are sweet potatoes, yellow maize, cassava, groundnuts, green gram, simsim, onions, beans and pawpaw. These are in addition to the sorghum and finger millet which the people have always planted. In several of the locations community centres have sprung up around the demonstration plots.

In the hills white maize, English potatoes, sweet potatoes, tobacco, beans and vegetables are the chief crops grown by the people. Several have modelled their *shambas* on the demonstration plots, where the same number of crops are grown, but on a smaller scale. Now that their catchment areas are protected and no cultivation or forest destruction allowed in them, several of the streams which rise in the hills have already become permanent. When I first arrived in 1931 these streams were in spate during the rains carrying much soil with them, but soon dried up after a few days fine weather. Now they are crystal-clear with a fairly even flow all the year round.

When the boys leave school on completion of their course, a large percentage of them go back to the reserve and start plots of their own, but owing to the lack of marketing facilities the majority have started smallholdings near Kapenguria. They are helped for the first year, and given a certain amount of supervision. Eventually they are self-supporting, using their own cattle for ploughing. A cattle shed, similar to the one at the school is erected, and the manure made in it used to keep up soil fertility. All these holdings are contour-ridged and in fact at the present time one would have to go far and wide in West Suk to find any *shamba* on sloping land that has not effective contour ridges in it.

The people in the lower parts of West Suk complained that yellow maize was too hard to grind, so the Local Native Council agreed to erect a water-driven grinding-mill at Tarana, a place near to four locations. This was put up in 1939 and has been a great boon. It is hoped to survey a site for another mill in the near future on the Murun River near Sigorror. In some of the more inaccessible locations hand-mills have been sent to the demonstration plots for use by the local Suk. The main obstacle to further agricultural progress and the marketing of crops is the lack of motor roads in the reserve. The plains, where groundnuts and simsim flourish have no road connexion at all to the outside world and any crops sold have to be transported either by donkeys or by the people themselves. A motor road through the Marich Pass to these plains is urgently needed.

Although several parts of the more badly eroded grazing-areas are now being rested, there is still much to be done in this direction. It is hoped to cut the thorn scrub and lay it in lines along the contours next year, both to act as wash-stops and also to catch grass seeds. Work should also be done on gully stopping. It will be some years before any appreciable number of Suk enclose paddocks for their stock. Last year Messrs. Liebigs bought over 3,000 head of cattle from the West Suk, and if this number is maintained annually, as well as grazing control, the grass cover should return to these overgrazed plains. The construction of dams in some of the areas where, owing to lack of water, the stock is at present unable to graze during the dry season would help in the more even distribution of grazing.

In conclusion, I should like to place on record the help I have received from the Administrative Officers in this work of agricultural development and education. They have not only been in sympathy with the various schemes suggested, but have done their utmost to see that they have been carried out. I have worked in close collaboration with the Agricultural Officer, Kitale, who has supplied seeds and planting material of good, disease-resistant strains. When Mr. Colin Maher, Officer in Charge, Soil Conservation Service, toured the district with me in January 1935, we formulated a soil conservation policy, the results of which can be seen in the flourishing condition of the district today.